PROCEEDINGS OF THE TWENTY-THIRD MEETING AND ACTIVITY REPORTS OF THE CANADIAN TREE IMPROVEMENT ASSOCIATION

CANADIAN TREE IMPROVEMENT ASSOCIATION
MAINTAINING
BIODIVERSITY
SHOULD WE BE CONCERNED?
OTTAWA 1991

COMPTES RENDUS DE LA VINGT-TROISIÈME CONFÉRENCE ET DES ACTIVITÉS DE L'ASSOCIATION CANADIENNE POUR L'AMÉLIORATION DES ARBRES

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OF THE

TWENTY-THIRD MEETING

OF THE

CANADIAN TREE IMPROVEMENT ASSOCIATION

MAINTAINING BIODIVERSITY "SHOULD WE BE CONCERNED?"

Held in
Ottawa, Ontario
August 19-23, 1991

Editors:

S. Magnussen, J. Lavereau & T.J. Boyle

COMPTES RENDUS

DE LA

VINGT-TROISIÈME CONFÉRENCE

DE

L'ASSOCIATION CANADIENNE POUR L'AMÉLIORATION DES ARBRES

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Outline of Forestry Canada's Deputy Minister J.C. Mercier Opening Address

to the

23rd Biennial Meeting of the C.T.I.A.

Welcome to participants on behalf of Forestry Canada

- Forestry Canada is pleased to continue its support for the Canadian Tree Improvement Association (CTIA).

- Forestry Canada recognizes the significant role that the CTIA has had in promoting the use of scientifically sound genetic practices in Canadian forestry.

- The CTIA is to be commended for having had the foresight, when first planning this meeting almost 2 years ago, to see the need to address the issue of biodiversity and the possible effects of tree improvement practices on it.

- Forestry Canada's sponsorship of this meeting acknowledges the importance it attaches to the issue of biodiversity.

Emergence of biodiversity as an important issue in Canada and globally

- Biological diversity (or biodiversity) has always been a fact of our environment.

- There have always been people who recognized that the rich biological diversity surrounding us was more than something to be admired, that it was the very basis for the survival of the human race as we know it.

- The difference today is that events are forcing an awareness of the importance of biodiversity on more and more people around the world.

- A very simple index of the increasing attention being paid to biodiversity is the large increase in the number of publications dealing with the issue. For example, a scan of titles cited in Biological Abstracts over the past ten years, shows that the number of titles referring to biodiversity have increased as follows:

1981 - 0
1982 - 0
1983 - 0
1984 - 0
1985 - 0
1986 - 0
1987 - 0
1988 - 0
1989 - 7
1990 - 30
first 3 months of 1991 - 37

- Even recently, many might have had difficulty explaining what biodiversity meant. Many still do, but now many suggested definitions can be found in the literature.

- Perhaps one of the best definitions of biodiversity is one proposed by the U.S. Government's Office of Technology Assessment, which reads as follows:

  "Biological diversity (i.e. biodiversity) refers to the variety (of) and variability among living organisms and the ecological complexes in which they occur.

  Diversity can be defined as the number of different items and their relative frequency. For biological diversity, these items are organized at many levels, ranging from complete ecosystems to the chemical structures that are the molecular basis of heredity. Thus, the term encompasses different ecosystems, species, genes and their relative abundance."

Why is there increased concern about biodiversity?

- Whether looked upon as a broad issue of biodiversity or as a narrower component, issues of genetic diversity, species diversity, and ecosystem diversity, raise compelling reasons for concern, such as:

  - a commitment to good stewardship of our natural resources

    In March 1991 Dr. Clark Binkley, Dean of the Faculty of Forestry at the University of British Columbia gave a special lecture at the University of Alberta; the title of his talk was: "Forestry after the end of nature".

    Dr. Binkley pointed out that:

    "foresters will have to produce more with less. Those lands managed for timber production will need to grow more wood per unit area and do it in an environmentally acceptable manner."

    This includes a need to understand both the effects of forest management and tree improvement practices on biodiversity in our forests, and the possible consequences of these effects.

    Dr. Binkley also pointed out that:

    "the public wants more than game, water and timber. And as foresters, we know the outlines of how to provide what the public wants. We understand the complicated linkages among parts of the ecosystem, and we know something about stewardship."

- need for ability to respond to climate change

  It is well recognized that genetic diversity will play a crucial role in enabling tree species to respond to and adapt to new environmental pressures, such as: exposure to outbreaks of new pests or pathogens, and the predicted effects of global climate change.

  Papers from Finland and Sweden pointed out that:

  "The uncertainty of changes associated with the greenhouse effect still seriously limits the possibilities of forest tree breeding to respond to them in advance. For the time being, the best way to prepare for the unpredictable future is to maintain the natural variability and adaptability of our forests."

  (Sources of the above information: The 1990 Annual Report of the Foundation for Forest Tree Breeding, Finland, containing an article by Jouni Mikola on "Forest tree breeding and the changing atmosphere." The issue of the importance of diversity as an opportunity to respond to climate change was also addressed by Eriksson (1990) in his paper on "Forest tree genetics for an uncertain future", published as a research note by the Swedish University of Agricultural Science.)

- the need to protect a resource of potential but unknown value

  On 19th July 1991, an article in the Ottawa Citizen contained the following statements:

  "Tropical rain forests are prized not only for the food, rubber and other commercial products that come from them, but especially for their vast variety of plants, birds, animals and insects."

  "Scientists see these as an important source of new medicines and other chemicals which, once destroyed, can never be revived."

  It is not necessary to go to the tropical forest for examples of trees as sources of medicines. For example, there is preliminary evidence that "taxol", extracted from the bark of the Pacific Yew tree, might be an effective treatment for ovarian and other cancers. The species is a minor component of the forests of British Columbia.

  In 1988 a symposium on "Conservation of Diversity in Forest Ecosystems" was held at the University of California. It identified the fact that forest geneticists had been calling for conservation of diversity for years - calling it gene conservation. Their reason was the need to "bank" a wide variety of genes for future breeding uses.

  However, by the time of the 1988 symposium it was clear that forest geneticists had become more acutely aware of the much broader issue. This was evident in statements made, such as:

  "Diversity has assumed a value in its own right as people turn to nature for recreation and solace. The existence of wilderness keeps our everyday world from becoming one large cage."

- Biodiversity Conservation - a moral as well as a practical imperative

  An article by Dr. Mostafa Tolba, Executive Director of the United Nations Environmental Program, stated that conserving biodiversity was a practical issue as:

  "the worlds natural species form the genetic storehouse for humanity's future agricultural and pharmaceutical developments....".

  He also stated that conserving biodiversity was a moral responsibility as:

  "human and non-human species have an equal right to exist on this planet."

  There are many other reasons one might think of. The few given above are obviously very broad in their scope, but at the same time, they are reasons that should concern us all.

Example of concerns for biodiversity

- Impact of urbanization and agriculture on tree species in the Carolinean forest of southern Ontario

  In an article in the the first issue of "Canadian Biodiversity", published by the Canadian Museum of Nature, Drs Schueler and McAllister stated that:

  "The biodiversity of Canada's forests is threatened by a number of human activities.".

  They expressed concern over:

  - clearing of forest for towns and farmland,
  - possible effects of planting of selected trees on natural gene pools, and
  - effects of cutting practices on components of the forest ecosystem other than trees.

Specifically they identified endangered tree species in the Carolinean Zone between lakes Erie and Huron. The same species are found in the United States, so species extinction is not the issue, but the suggestion is made that these Canadian representatives may have developed unique adaptations to survive.

What is Forestry Canada doing to address the biodiversity issue?

- In Canada

  - Strategic Plan commitment to sustainable development

    Forestry Canada's recognition of the importance of biodiversity and its commitment to address the issue are clearly implicit in the following mission statement contained in the Forestry Canada Strategic Plan, published in 1990:

    "To promote the sustainable development and competitiveness of the Canadian forest sector for the well-being of present and future generations of Canadians.".

    This brief mission statement unequivocally confirms Forestry Canada's acceptance of and support for the broad concept and principles of sustainable development, defined in the Strategic Plan as follows:

    "Sustainable development of the forests and their multiple environmental values involves fostering, without unacceptable impairment, the productivity, renewal capacity, and species diversity of forest ecosystems."

    The obvious linkage between a commitment to sustainable development and maintenance of biodiversity within the context of forest management is also evident in the following statement from the Strategic Plan:

    "The Canadian Forest Community has traditionally been strongly committed to the principle of sustained timber yield. The concept of sustainable development encompasses this notion but is broader to include the flow of non-timber values such as wildlife and fisheries habitats, watersheds and hydrological cycles, and gene pools and species diversity."

    A review of research and development activities at Forestry Canada centres across the country would show that important components of the biodiversity issue are being addressed. One specific initiative is the following:

  - Strategic Plan commitment to establish a Gene Pool Centre

    In its Strategic Plan, Forestry Canada recognized the need for action:

    "to protect our forest heritage both at home and abroad and to counteract global atmospheric change".

    The decision was made to:

    "establish a national tree gene pool centre to ensure that forest gene pools will be maintained and available for future research and utilization".

    Action is being taken to establish this centre at Petawawa National Forestry Institute, through reallocation of existing resources.

    The scope of this initiative has subsequently been enhanced through the support of the government's Green Plan.

The Green Plan initiative is described as follows:

"The aims of this initiative are two fold: to establish and operate a national forest genetic resources and biodiversity centre, so as to ensure the preservation of unique forest genetic materials of all types; and to support research on such related topics as germplasm conservation techniques, impact of forestry practices on biodiversity, and the effects of natural and artificial selection on genetic diversity. The Centre will be established at the Petawawa National Forestry Institute.".

Staff at PNFI and in the Science and Sustainable Development Directorate, Forestry Canada HQ, are already actively pursuing establishment of the Centre.

- Other Green Plan initiatives

  Biodiversity and associated issues will also be considered in other important initiatives such as the establishment of model forests.

- Internationally

  - ASEAN/Canada Forest Tree Seed Centre, Thailand

    Petawawa National Forestry Institute (Forestry Canada) was appointed by the Canadian International Development Agency (in 1989) as the Canadian Executing Agency (CEA) responsible for delivery of Phase II of the ASEAN/Canada Forest Tree Seed Centre Project.

    (ASEAN = Association of Southeast Asian Nations, including member countries: Brunei, Indonesia, Malaysia, Philippines, Singapore, and Thailand.)

    Over the past few years PNFI and associated contractors have contributed substantial scientific and management expertise to this project which has the overall objective to:

    "Increase the supply of quality forest tree seed and materials for vegetative propagation required for the ASEAN forestation programs and to protect the genetic diversity of ASEAN forests.".

    Protection of genetic diversity, including planning and establishment of gene conservation areas will be important activities in this project.

  - SADCC Tree Seed Centre Network Project

    (SADCC = Southern African Development Coordination Conference. Member countries: Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia, and Zimbabwe, plus Namibia if it joins after gaining its independence)

    Since 1987 Forestry Canada (PNFI) staff have been giving input to this project being planned by the Canadian International Development Agency.

The Project aims at national and regional self-sufficiency in tree seed and germplasm. Research associated with this project will generate much needed knowledge of the biology of seeds of indigenous species and of their genetic diversity.

- Canada's role in development of UNEP Convention on Biodiversity

  Forestry Canada is active in providing input to the definition of Canada's position on the Convention on Biodiversity.

  This Convention, being developed by UNEP in cooperation with IUCN, is intended to be **"an international legal instrument for the conservation of biodiversity."**

  (UNEP = United Nations Environmental Program)
  (IUCN = International Union for the Conservation of Nature and Natural Resources)

Closing comments on the meeting and its purpose

- This meeting:	starts with a	**QUESTION,**
	to which it will give an	**ANSWER,**
	and will leave you with a	**CHALLENGE.**

The Question:

Maintaining Biodiversity - Should We be Concerned?

The Answer:

The answer is already evident in the actions of Forestry Canada and others, and will, I believe, be confirmed in the message that the speakers will bring.

Yes! You, and everyone of us, should be concerned:

- about maintenance of biodiversity,
- about how our own actions affect it,
- about the possible long term consequences for all of us,
- to do your (our) part to acquire and apply the knowledge needed to ensure a future for biodiversity - and probably for the human race. This is your **CHALLENGE!**

  Your meeting this week, addressing the issue of biodiversity, is a step in the right direction, and I wish you every success.

IN MEMORY OF

IN MEMORY OF A. CORRIVEAU

La période 1989-1991 a été marquée par le décès de notre confrère Armand Corriveau. Nous voudrions profiter de l'occasion qui nous est offerte pour lui rendre hommage et pour souligner son implication en génétique forestière et dans notre association.

Armand Corriveau est né le 26 septembre 1945 à Saint-Vallier-de-Bellechasse, Québec, Canada, et est décédé le 3 novembre 1990 à Sainte-Foy, Québec, Canada. En 1969, il complète ses premières études universitaires et obtient un baccalauréat en génie forestier de l'Université Laval. Au cours de la même année, il entre à l'emploi de Forêts Canada comme agent de recherches en sylviculture. En 1971, il s'inscrit à un programme de doctorat en génétique forestière au North Carolina State University sous la direction du Dr Bruce Zobel. En 1974, le Dr Corriveau revient au Canada où il prend en charge le programme d'amélioration génétique initié au Québec par l'Institut forestier national de Petawawa et poursuivi par le Dr Lawrence Roche. Il restructure alors le projet de recherches dont il a la responsabilité et s'entend avec les chercheurs du ministère des Forêts du Québec sur une division du travail pour éviter les duplications. Armand utilise alors toute son influence scientifique pour faire progresser le plus rapidement possible les travaux de recherches sur la génétique et l'amélioration de l'épinette blanche et de l'épicea commun. Ayant de plus toujours été frappé par la force tranquille de ce géant qu'est le pin blanc qui collonise la vallée du Saint-Laurent où il a grandit et par le trop peu d'attention qu'on y porte, il décide d'entreprendre son amélioration génétique.

Aujourd'hui, près d'une cinquantaine de tests génécologiques sont implantés au Québec desquels on tire déjà des informations essentielles à la conduite de programmes d'amélioration génétique éclairés. Armand ayant aussi toujours été un homme de vision s'est assuré de l'utilisation de tous les outils biotechnologiques nécessaires à une obtention rapide des gains recherchés. Il s'est également impliqué dans notre association soit en présentant ses résultats de recherches ou en organisant des conférences. Il est l'auteur d'au-delà d'une trentaine d'articles scientifiques, rapports d'information et compte-rendus.

Il laisse à son départ un projet de recherches bien structuré regroupant des collègues à qui il a transmis son goût du travail bien fait, son attachement à la nature, un souvenir d'une très grande disponibilité et des moments de discussions enrichissants.

Jean Beaulieu
Forêts Canada - Région du Québec

Eulogy: Dr. Carl C. Heimburger

Carl Heimburger was born in St. Petersburg/ Leningrad, Russia of at least part Danish parentage, in 1899 and lived a full and exciting life for most of his 91 years. He died on southern Vancouver Island in 1990.

Previous accounts (eg. Fowler, D.P. & M.D. Meagher, 1990, For. Chron., June.) have detailed his accomplishments and some of these should be mentioned. He matriculated in St. Petersburg in 1990 where he also became interested in plant breeding, a subject which stayed with him for life. Moving to Copenhagen, Denmark he studied forestry at The Royal Veterinary and Agricultural College, graduating in 1924.

After emigrating to Canada in 1925 he enrolled and subsequently graduated from The Faculty of Forestry, University of Toronto in 1928. This was followed by earning his Ph.D. from Cornell University in 1933.

It is worth noting who some of his colleagues were at Cornell. Lars Gunner Romell, who became the great Swedish forest ecologist, and W.H. Pearsall who became the similarly ranked British plant ecologist, were both doing research at Cornell at that time. Carl, Lars Gunner and 'Willy' P. were good friends and in their collective studies were measuring nitrate (NO_3) and its role in forest soils. Theirs were probably the first studies of North American forest soils on this subject, and while since long neglected, has become so important in the 1980's and '90s.

Carl Heimburger's published thesis, "The Forest Type Studies in The Adirondack Region" is not only a classic, but a major ecological work, long anticipating many of the studies eg. F.E.C. (Forest Ecological Classification) which are proceeding today. Speaking as someone working in the genus *Picea* one can say that Heimburger certainly knew his spruce sites and identities, as few others did.

I am reminded that Mark Holst, another 'Great Dane' and young friend of Heimburger's told me one day that "Heimy's progeny trials almost always did very well because he was also such a good forest site ecologist that he invariably set them out on the most appropriate sites!"

Throughout the developmental stage of his career he worked for a number of companies in Finland, Sweden, Quebec and British Columbia and then with the Dominion Forestry Service from 1934 to 1945. He then joined The Research Division of The Ontario Department of Lands and Forests (Ministry of Natural Resources) at Maple, where he worked from 1946 until after his official retirement in 1968.

He initially published work concerning observations on spruce biogeography and genetic variation, moving from there into accounts of breeding in *Pinus*, particularly white pine, and *Populus*. He addressed accounts of forest tree breeding and genetics in Canada to The Genetics Society of Canada, and as an outgrowth, was instrumental in organizing, and subsequently as an occasional executive member, guiding The Committee on Forest Tree Breeding in Canada, which has since become this Canadian Tree Improvement Association. He was honoured by The Royal Society of Canada, the only forester thus far elected "Fellow"; The Canadian Institute of Forestry: Fellow; and in 1983 a post-retirement honour by The Ontario Ministry of Natural Resources. He was a Canadian editor of Sylva Genetica.

His cultured and charming wife, Dr. Margaret (Landes) Heimburger, was, in her own right, a very respected plant geneticist who worked for many years in The Department of Botany, University of Toronto, on anemones.

What can one say about Carl Heimburger? He spoke fluent Danish, Russian and French and, on occasion, somewhat explosive English. Any of the former could easily identify him as a country-man. He was exacting and demanding, not only of others, but of himself. He suffered fools lightly and, occasionally to his own detriment, generally made this known. However, he was honest in debate and to those who risked good scientific argument with him, he retaliated with friendship and support. He was a friend and mentor of a small number of young forest geneticists, Mark Holst, Don Fowler and myself among others, and helped many others he did not know.

His final contribution, most appropriately presented to the C.T.I.A. in 1983, was a thoughtful presentation on his perceptions of the genetic origins and "evolution of black spruce". He has left many of us with his hand on our shoulders and his insights in our minds, while his genetic material still contributes to genetic advancement in many breeding centres.

A.G. Gordon
Ontario Ministry of Natural Resources

PART I

THE CONFERENCE

ABSTRACTS OF INVITED SYMPOSIA PAPERS[1]

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[1] Full length papers will appear in a dedicated issue of the Forestry Chronicle.

BIODIVERSITY AND FORESTRY

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Understanding genetic structure, dynamics, diversity, and management for a few plant species is a lifetime career. Understanding species association, interspecific dynamics, diversity, and management for a few associations is a lifetime career. Understanding the relationship between intra- and inter-species associations and its structure, dynamics, diversity, and management for a few species in a few paradigm associations is a lifetime career. Yet, we are faced with unprecedented pressures on habitats, species, and gene systems. To understand and manage biodiversity requires a broader perspective than our fragmented forested profession now has.

BIODIVERSITY IN CANADIAN FORESTRY

T.J.B. Boyle

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The current state of knowledge of the biodiversity in Canadian forests is examined, together with an assessment of current conservation programs, both *in situ* and *ex situ*. Research results and ongoing research related to forest biodiversity being undertaken in Canada are discussed. Gaps in present knowledge that are identified. Possible impacts of various domestic and international initiatives of forest biodiversity and forest management are discussed.

INTERNATIONAL ASPECTS OF BIODIVERSITY

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Major new initiatives and strategic planning are underway on international work on biodiversity, especially in relation to the United Nations Conference on the Environment and Development to be held in 1992. An outline is given on how work on conservation and utilization of plant genetic resources has progressed over the past 25 years, and how current efforts need to be modified in the light of new scientific developments. For trees, more emphasis needs to be placed on *ex situ* conservation in order to back sustainable production forestry, prevent further loss of biological diversity, and to support ITTO's goal for 2000 as the date by which all internationally traded tropical timber would have to be derived from sustainable sources.

RATIONALE FOR PRESERVING CROP GENETIC DIVERSITY

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Genetic erosion is a term used to describe loss of variability in crop gene pools. Genetic vulnerability refers to the narrow genetic base of varieties grown in the field. Genetic resources centres were established worldwide to counteract the effect of these factors by preserving crop genetic diversity and by facilitating its use in research and plant breeding.

THE POTENTIAL EFFECTS OF GLOBAL CLIMATE CHANGE ON THE BIODIVERSITY OF WOODY PLANTS

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Climatologists predict a doubling of atmospheric CO_2 during the next 100 years. Climate models vary in predicting how doubling CO_2 will affect North American climate, but generally agree on three points: mean summer and winter temperature will increase between 2° and 5°C, temperature changes will be greater at high latitude and mid-continental regions will experience lower rainfall. The effect of these phenomena on biodiversity is likely to be dramatic. Predictions of species range shifts in response to climate change vary from 250 to 500 km. These predicted future ranges are non-overlapping with current range limits for many trees. Historical evidence of species range movements following the Pleistocene indicate that tree species migrated at rates between 10 and 45 km per century. These estimates probably approximate maximum migration rates for trees. The movement of trees through the modern landscape may be slowed by as much as 50% because of habitat reduction and fragmentation. This model predicts that trees will not come to climatic equilibrium for at least a millennium. Differential migration rates between species will result in now contacts between species with unpredictable ramifications. Insects and microbial pathogens should respond to climatic warming faster than long-lived trees. Predicted increases in the incidence of drought should increase plant stress and thereby increase the frequency of insect outbreaks and disease. In addition, it is predicted that exotic weeds will expand their ranges to become pests where they currently are not. These simple models of species response are further complicated by numerous additional factors for which there is little information. For instance, elevated CO_2 increases water-use efficiency and enhances growth in many plants. However, response to elevated CO_2 varies among species. Thus reproductive and competitive abilities of species may shift within their current habitats. While one could move trees to compensate for their response lag to climate change, the knowledge to predict how far species can safely be moved is lacking. Much needs to be learned with respect to the exact climatic variables that limit individual species' ranges. Finally, range shifts and disease may exert a strong selective pressure on tree populations. While it remains to be seen which species will survive under these diverse selective pressures, we can target species that are likely to be vulnerable based on on range size and habitat specificity.

BIOTECHNOLOGY AND BIODIVERSITY - THE INTERRELATIONSHIPS

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Although the two current high profile scientific fields of biotechnology and biodiversity have extremely different scientific foundations and philosophies, they are still closely interrelated. Forest biotechnology to be useful is dependent on the availability and maintenance of a broad genetic foundation. Such a foundation is best achieved over time by maintaining the biological diversity of natural systems. In contrast, it is conceivable that with the release of genetically engineering organisms, natural biological diversity could be negatively impacted. The possibility of such an influence will be discussed. Finally, the politics of the relationship between these two emerging scientific fields will be briefly reviewed.

BREEDING STRATEGIES IN A CHANGING CLIMATE AND IMPLICATIONS FOR GENETIC DIVERSITY

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Most global climate models predict a rapid increase in temperature over the next few decades as a result of elevated levels of CO_2 and other greenhouse gases. Although the resolution of the existing models is not sufficient to predict specific weather patterns for Canada's Maritimes Region, the predicted rate of change is such that forest tree populations will be unable to adapt fully to future conditions. If conventional rotation lengths are planned, presently adapted seedlings will be poorly adapted to the new conditions by the time of harvest. A three-pronged approach is proposed to mitigate the impact of climate change in the Maritimes: development of short rotation clonal forestry, testing and breeding for stability of genotypes over a range of climatic conditions and collections, storage and testing of native and non-native materials of potential value.

ABSTRACTS OF
WORKSHOP CONTRIBUTIONS

Population Genetics

Chaired by Dr. F.C. Yeh, University of Alberta

DOMESTICATION AND GENETIC DIVERSITY - SHOULD WE BE CONCERNED?

Y.A. El-Kassaby

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Despite the fact that forest trees are in their early stages of domestication, there has been little direct evaluation of the genetic diversity throughout this process. The dynamic changes in the genetic structure of wild conifers were monitored through several bottlenecks, namely: phenotypic selection, seed orchards, seed processing and storage methods, and seedling production. The genetic structure of phenotypically vs. randomly selected individuals of two conifers with known contrasting diversity levels is compared. The biology and management methods practiced in seed orchards are evaluated, and seed extraction and storage procedures are assessed to evaluate common practices on biological peculiarity. Finally, the cultural practices of container nurseries were monitored and their impact on the genetic structure of future forests is evaluated.

GENETIC DIVERSITY OF CANADIAN HARDWOODS: IMPLICATIONS FOR CONSERVATION

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Hardwoods occupy a large portion of several forest ecosystems found in Canada. Collectively, they have long been the neglected child in Canadian forest genetics and tree improvement. Even though the ecological status of many Canadian hardwoods is relatively well known, their genetic diversity, genecology, mating system and population structure remain to be deciphered. Abundant natural regeneration for several species, high costs associated with seedling production and plantation establishment, low demand from the pulp and paper sector, and lack of strategies in dealing with the numerous private owners of the southern Canadian forest have refrained the industry and the governments from investing into basic biological and genetic research of hardwoods species. However, this situation is changing rapidly and new interests have emerged for genetic improvement and conservation of hardwoods species. Fast growing species such as red alder, trembling aspen or birch can be found as major components of the mixed boreal forest, and are becoming economically important. In the southern part of eastern Canada, the rich mixed hardwood forest contains numerous major and minor species of high economic value. Most of these forests have suffered from intensive harvesting during the past 200 years, and some are affected by declines. We review our current knowledge of the organization of genetic diversity in the few Canadian hardwood species that have been studied. Studies derived from the analyses of quantitative characters showed extensive genetic variation that could be used in improvement programs. Biochemical markers such as isozymes have shown that the levels of genetic diversity and population structure were quite similar to those reported for conifer species. Programs aimed at studying population genetic aspects of hardwoods and establishing conservation and improvement programs are currently developed nationwide. New strategies at the DNA level that could help monitor genetic diversity of these species will be discussed.

TREE BIODIVERSITY AND THE PRESERVATION OF NEWFOUNDLAND PINES

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Red pine, *Pinus resinosa* Ait., is a rare species in Newfoundland with an extant population of less than 10,000 trees located in 20 small stands that are clustered in 2 main population centres on an Island with an area of about 115,000 km^2. The decline of red pine, the extinction of natural populations is an ecological and economical concern on an Island with a limited biodiversity in tree species, and a limited resource base for commercial exploitation. Native pines have an important ecological role on dry sties that cannot support productive forests of other species. Seedlings from a sample of trees from most of the extant natural populations are being established at several "safe" sites to preserve the Island's gene pool. However, molecular genetic studies that are underway to characterize genetic variation suggest that Newfoundland populations of red pine remain largely undifferentiated from mainland populations. Ecological studies on seed production indicate that reproductive success in red pine populations from the interior of the Island is comparable to that of mainland populations. Adverse spring weather during flowering and pollination period (in coastal populations), natural successional trends, overcutting, and fire suppression are among the factors that may limit red pine's success as a naturally occurring species on the Island. In this article, we use Newfoundland's red pine population as an example for broader discussion of concepts in population ecology and genetics that can guide our approach to the conservation and genetic management of species with fragmented distributions and small population sizes.

GENETIC CONSEQUENCES OF FOREST FRAGMENTATION FOR SUGAR MAPLE POPULATIONS

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Forest fragmentation, the dissection of large continuous forests into small spatially discrete forest patches, is a global phenomenon. However, little is known about its affects on the genetic structure of forest tree populations. Data from natural populations of different sizes have been used to provide some insight into this question, suggesting that fragmentation may result in reduced genetic variation and increased population differentiation. Recent data from sugar maple populations, in both fragmented and continuous forests, indicate that such extrapolation may be unjustified. Small forest patches were found to exhibit elevated levels of within population and within individual variation. These data suggest mechanisms that are important in generating and partitioning genetic variation within fragmented forests.

(11)

GENETIC CONSEQUENCES OF *IN SITU* AND *EX SITU* CONSERVATION OF FOREST TREES

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To counteract the accelerating loss of genetic diversity crucial for current and future tree improvement, forest genetic resources have been either conserved *in situ* in their natural ecosystems (undisturbed reservoirs) or exploited and maintained in controlled (*ex situ*) environments (breeding arboreta, seed orchards, and test plantations). What is the best means of conserving genetic resources has been the subject of debate and the focus of research. This paper first reviews previous studies on population structures of forest tree species in the context of their impact on the choice of conservation methods. Using available theory and isozyme data, we address the following issues: What are the features of population structure that differentiate *in situ* and *ex situ* conservation? How does knowledge pertaining to the genetic structure of a natural population help to implement an efficient and practical strategy for *ex situ* conservation and/or tree improvement? Does the presence of multilocus structure of a population suggest a different strategy? Do *ex situ* conserved populations provide enough genetic variation for future tree improvement? What is the practicality of implementing an *in situ* conservation program? The second part of this paper deals with the monitoring of genetic changes in conserved populations. Do *in situ* and *ex situ* conservation lead to different genetic structures of populations? The answer to this question can be found in two ways: prediction of long-term behaviour and direct measurement of genetic variation in conserved populations. Both prediction from simple genetic models and empirical studies show that genetic diversity in *ex situ* conserved populations decreases considerably over generations, compared with the natural populations. We conclude that while *ex situ* conservation is a convenient operational program for short-term tree improvement, *in situ* conservation is essential to explore new genetic variation to meet the changing environments in the future.

ABSTRACTS OF WORKSHOP CONTRIBUTIONS

Wood Quality

Chaired by J. Gonzalez, Forintek

ALLOCATION OF VARIANCE IN RELATIVE DENSITY OF WOOD FROM NORTHWESTERN CONIFERS

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and

L. Jozsa and J. Gonzalez
Forintek Canada Corp., Vancouver, B.C.

Relative density is a complex trait reflecting contributions from earlywood and latewood density and their proportions. Distribution of variance among 15 components of variance was compared for species with markedly different patterns of wood formation and for different ages. The species analysed were Douglas-fir, Sitka spruce, western larch, western red cedar, and yellow cypress.

EFFECT OF SPACING ON WOOD DENSITY ESTIMATION IN EARLY TESTING OF DOUGLAS-FIR

Y.A. El-Kassaby

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A partial six-parent diallel of Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco] planted at two spacings (15 x 15 and 15 x 30 cm) was destructively measured three years after germination. The objective of the study was to determine the extent of genetic control on yearly ring width (RW) and density (RD) as affected by spacing. The total phenotypic variance of yearly RW and RD were partitioned into genetic, environmental (spacing), genetic-spacing and random error effects to permit the determination of heritability and genotype x spacing interaction. Significant genetic [general (GCA) and specific (SCA) combining abilities], spacing, and spacing x GCA effects were obtained. The SCA variance component was larger than that for GCA, however, the relationship between SCA and GCA variance components showed a consistent decline of SCA over the three studied years. Conversely, the GCA effect was virtually non-existent in the first year and steadily increased over the three year period. Although only six parents were studied, significant GCA x spacing effects were observed. The implications of this interaction on early testing is discussed.

GENETIC AND PHENOTYPIC RELATIONSHIPS BETWEEN GROWTH AND WOOD RELATIVE DENSITY OF INTERIOR SPRUCE

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Juvenile wood relative density (RD) was assessed by the maximum-moisture content (MMC) method in 40 open-pollinated families of interior spruce growing in two 15-year-old progeny tests of north-central British Columbia to examine: (1) the magnitude of family differences; (2) phenotypic, genetic and family mean correlations between RD and growth traits, and; (3) develop an approach for using these parameters for the prediction of parental breeding values. Differences among the 40 families for mean RD were large (0.38 to 0.44), as indicated by high individual ($h^2_f = 0.47\pm0.03$) and family mean ($h^2_f = 0.67\pm0.11$) heritabilities. Genetic correlations between both height growth and diameter growth and RD were near zero, whereas phenotypic correlations were significant ($P<0.05$) at -0.40 and -0.46, respectively. Family differences using the Pilodyn (PIN) apparatus as an indirect measure of RD were significant ($P<0.05$) and exhibited a moderate family heritability (0.48±0.25). The genetic correlation between PIN and RD as assessed by the MMC method was -0.80±0.10. Family selection for RD using PIN data was expected to be 67% as efficient as direct family selection for RD based on the MMC values. Parental breeding value predictions for height growth and RD, using the PIN at age 15, indicate that no reduction in RD from family selection is likely. Moreover, it appears that the selection of families with high positive breeding values for both traits is possible.

SPECIFIC GRAVITY — ANOTHER SELECTION TRAIT FOR A HYBRID POPLAR CLONAL SCREENING PROGRAM?

A. Mirza and S. Strobl

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Specific gravity is of key importance in forest product manufacture because it has a major effect on both quality and yield of pulp, energy, and solid wood products. The hybrid poplar tree improvement program in eastern Ontario uses multiple-stage clonal selection. New clones are selected for Septoria canker resistance, good rooting ability and photoperiodic adaption, and fast early growth. To investigate the potential of including wood quality as a fifth selection trait, two studies were recently undertaken.

In the first study, specific gravity was evaluated for thirty randomly selected individuals from seven hybrid poplar families to explore variability in the trait. Height, root collar diameter, and Septoria canker severity were also measured to determine correlations between these traits and specific gravity. Two samples for wood quality testing were taken from each stem: one at 10% of the distance from whorl to butt and another at 10% of the distance from whorl to tip. Specific gravity was determined on a green volume basis using the volume by water immersion method. Moisture content was determined gravimetrically on an oven-dried basis. Results showed significant (p=0.0001) differences between families with those of *P. deltoides* x *maximowiczii* parentage ranking first, second, and third with respect to specific gravity. Families with *P. deltoides* x *nigra* parentage were generally more resistant to canker. Variability within and between families was high. Coefficients of variation ranged from 28.4 for family 2253 to 87.1 for family 2296.

To determine the best place for wood quality selection within the multiple-stage program, a second study investigated juvenile:mature correlations in specific gravity. Sample cores were cut from disks taken at the centre of each internode for ten eleven-year-old trees of clone DN74. Ring widths and densities were recorded for each sample using the X-ray densitometry method. Whole-tree specific gravity at two or three years of age will be compared to that of rotation age material.

ABSTRACTS OF WORKSHOP CONTRIBUTIONS

Tree Seeds:
Crown Management for Cone Production

Chaired by R. Smith, Forestry Canada, Maritimes Region

CROWN MANAGEMENT — ARE WE APPLYING WHAT WE KNOW?

Ron Smith
Forestry Canada - Maritimes

Past and ongoing research on crown management in conifers was reviewed. While there is a good information base on the spatial (crown-shoot-bud) patterns of reproductive and vegetative bud development in conifers, as well as the temporal patterns (initiation/differentiation), little is known about the physiological control mechanisms. Consequently, virtually all of the research into crown management conducted to-date has focused on empirical measurements.

Crown management studies in black and white spruce in the Maritimes were reviewed in the context of developing a crown management regime as part of a seed orchard management system. Response to topping treatments was affected by the timing, frequency, and severity of topping, as well as tree species and age. Potential problems associated with topping such as changes in sexual zonation within the crown, and affects on seed and pollen cone production while present, have not been shown to be of major consequence in spruce trees receiving regular, light toppings.

Crown management should be combined with cone induction and other cultural practices in both conventional seed orchards as well as non-conventional orchards e.g., meadow orchards and breeding halls.

DEVELOPMENT OF THE CROWN AND OF THE PATTERN OF CONE DISTRIBUTION: THE STARTING POINT FOR CROWN MANAGEMENT FOR SUSTAINED CONE PRODUCTION

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To understand patterns of cone distribution in the crowns of common genera one must first understand the various patterns of development of the structure of the crown. These patterns of development involve (i) character of the structures, such as morphological nature of short and long shoots, proportion of performed and neoformed extension of shoots, or proportion of proleptic and sylleptic branching; (ii) orientation of shoots, whether inherently orthotropic or plagiotropic, or plagiotropic by imposition; (iii) amount of development, such as differences in shoot lengths down crowns or inward on branches; and (iv) timing of events, such as budburst, the period of steady shoot elongation, and bud formation, and rate of shoot elongation. Although some patterns occur in several genera, others are monogeneric, or are expressed to varying extent in different genera. The crown of each genus, and sometimes species, must be understood as developing in a distinct way. Development of the long-shoot crown structure of

Pinus strobus, P. monticola, P. resinosa and *P. ponderosa* may be considered simple. Crown structure of *Pinus banksiana* and *P. contorta* is more complex because of multinodality, with intermediate whorls of preformed branches decreasing in initial vigour acropetally while main whorls of branches decrease in vigour of extension basipetally. Crown structure of *Picea* is also made complex by the many preformed "interwhorl" branches that decrease in vigour basipetally. Young *Picea* may exhibit some neoformed extension, but later, all extension is preformed. *Larix* crowns have great complexity not only because of production of short shoots and long shoots, both vastly different in character from those of *Pinus*, but also because of retention into old age of a propensity for large proportions of neoformed extension of long shoots, and, in younger trees, production of sylleptic branches. These varying patterns are related to how cones are borne in the crowns and along the individual shoots. In each genus distinct patterns of cone distribution become evident as crowns bear cones for the first time and then increase their capacity for cone bearing. Again, complexity of patterns of distribution vary with genus, and probably, as in *Pinus*, with species. If one is to manipulate crowns with the objective of sustaining cone production, one must take into account the patterns evident in structural development and in both seed-cone and pollen-cone distribution.

CROWN RESPONSES AND STROBILI PRODUCTION IN TOP-PRUNED JACK PINE SEED ORCHARD TREES

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The effects of top-pruning were examined on 9-year-old jack pine seed orchard trees over a three year period. In 1987, light topping removed the developing current leader and the 1986 main-stem internode: severe topping removed the leader, two years of previous growth and the 1984 internode. A single replacement stem developed on lightly topped trees the year following treatment. Multiple replacement stems occurred on severely topped trees but required 3 years to develop. Senescence of older branches at the bottom of the crown was reduced by topping. Production of seed strobili on lightly topped trees was unaffected in the following 3 years but on severe trees, production remained significantly lower than control trees. Seed strobili production increased on the uppermost branches of topped trees at the expense of pollen strobili.

ABSTRACTS OF WORKSHOP CONTRIBUTIONS

Biotechnology in Tree Improvement and Impact on Biodiversity

Chaired by P.J. Charest, Forestry Canada, PNFI

ASPECTS OF BIOTECHNOLOGY AND BIODIVERSITY

Pierre J. Charest

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Molecular Genetics and Tissue Culture
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Biotechnology can be related to genetic biodiversity in many ways and it can be seen as a help or as a threat. Help can be found in applications such as tissue culture for germplasm preservation or DNA fingerprinting for characterization of genetic biodiversity. Threat can be envisioned with the use of clonal forestry by reducing biodiversity or with genetic engineering by potential of genetic pollution. However, the overall goal of biotechnology is to increase artificial forest productivity so that natural forests can be left untouched. Consequently, preserving natural biodiversity. During the course of this workshop, an overview of research trends in Canada and abroad will be given, with some insights on integrated pest management. There will be a presentation on the use of tissue culture in a tree improvement program and on the use of molecular biology to analyze biodiversity. As an example of clonal propagation, an overview will be presented of the accelerated tree improvement program of J.D. Irving Co. Ltd. Finally, there will be a subjective view of the impacts of biotechnology related to genetic engineering on forest ecosystems.

OVERVIEW OF RESEARCH TRENDS IN BIOTECHNOLOGY IN CANADA AND ABROAD

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Biotechnology research done in Canada has been pioneering the areas related to forestry in the world. Good success stories exist with the large scale field application of *Bacillus thuringiensis* against spruce budworm and the use of viruses for the control of other insects. Biotechnology research related to trees has made tremendous advances in the areas of conifer somatic embryogenesis (spruce and larches) and cryopreservation of these tissues. Major efforts are being put together in Canada by Silvagen and by J.D. Irving Co. Ltd. to develop the somatic embryogenesis to a commercial level. In addition, work done at PNFI has pioneered the area of regeneration of tree species from larch protoplasts (single cells). Genetic engineering has been successful in producing transgenic poplar trees that are now undergoing fielding testing and environmental impact assessments. Moreover, a breakthrough with a marker gene (b-glucuronidase) in the regeneration of somatic embryos of white spruce has been achieved and lead the way to exciting molecular biology spruce species.

APPLICATION OF SOMATIC EMBRYOGENESIS IN TREE IMPROVEMENT PROGRAMS

Ben Sutton, Dane Roberts, Fiona Webster, Steve Grossnickle,
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Somatic embryogenesis (SE) is a tissue culture system with the potential to rapidly multiply improved seed and accelerate its introduction into operational reforestation. In addition, since it is possible to store clonal material in a regenerative state for extended periods, it allows for clonal selection and subsequent clonal forestry. This presentation covers the basic properties of the tissue culture system and the results of a range of assessments for phenotypic quality and genetic stability of material produced from SE. Its application in tree improvement and the implications for biodiversity are discussed in the context of forestry in British Columbia.

A NOVEL APPLICATION OF MOLECULAR TECHNOLOGIES FOR ASSESSMENT OF BIODIVERSITY

Bob Rutledge

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Recent breakthroughs in the understanding of gene function have led molecular biology into a revolutionary period, which is providing an unprecedented understanding of the molecular basis for the regulation of cellular development and intracellular signal transduction. These discoveries are now providing the foundation for what can be best described as a unified molecular theory for cellular function and development (Science 251, page 1176 (1991)). In addition to resolving the fundamental aspects of cellular differentiation, is an intriguing opportunity to address the basic mechanisms underlying morphological character, in a manner that is potentially applicable to both tree breeding and the assessment of population biodiversity.

Our molecular genetics group at PNFI has utilized the Polymerase Chain Reaction (PCR) to isolate and character segments of several conifer gene families, including homologs to the flower homeotic genes and myb-related genes. We have confirmed that conifers do possess homologous genes, and that these genes comprised very large gene families containing 20-50 genes each. Although our major objective is to examine the role of these genes in the regulation of embryo development, an examination of variation within these gene families within a population, may provide an opportunity to directly evaluate the genetic component determining morphological variations between individuals. Specifically, based upon the demonstrated importance of TAF (trans acting factors) genes in morphology suggests that study into the variation of the type and composition of these genes within a population, may provide important insights into the molecular basis for biodiversity within a specific tree species.

ACCELERATED TREE IMPROVEMENT PROGRAM: INTEGRATING NEW TECHNOLOGIES

G.W. Adams

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Accelerated breeding techniques for black spruce have been developed to the stage where they are being incorporated into the tree improvement program. Clonal propagation by rooted cuttings or possibly somatic embryogenesis may soon be economically justifiable as control-pollinated seed becomes available from second generation selections. The full length paper discusses accelerated breeding techniques and clonal propagation and how they may be utilized in long-term breeding and production strategies for black spruce.

IMPACT OF BIOTECHNOLOGY ON FOREST ECOSYSTEMS

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The impact of biotechnology on forest ecosystems is discussed. The application of biotechnology in Canadian forests will bring about characteristics of high-yield forestry. Desirable impacts of biotechnology are increased forest productivity, reduced pressure on forest lands, and increased forest management. Undesirable impacts of biotechnology include pest adaptations to new pesticides, non-target pest emergence, reduction of biodiversity, genetic pollution and new evolutionary tracts. In order to minimize the negative impact of biotechnology policies controlling the use of biotechnology in Canadian forests should be enacted. These policies should emphasize the understanding of the ecological effects of biotechnology and integrated forest management.

ABSTRACTS OF WORKSHOP CONTRIBUTIONS

North American Quantitative Forest Genetics Group

Chaired by J. Loo-Dinkins, Forestry Canada, Maritimes Region

MINIMUM CLONE NUMBERS REQUIRED IN PRODUCTION SEED-ORCHARDS AND CLONAL PLANTATIONS

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When estimating minimum and optimum numbers of clones for deployment in clonal forestry, the following considerations seem important: (1) Risk to a random genotype from biotic and/or physical damage; (2) The level of unacceptable loss; (3) Diversity among the deployed clones; (4) Gain changes with changed selection differential; (5) Stability in both WIMP and MOMS configurations; (6) Rotation time from planting to harvest; (7) Management comprehension and efficiencies; (8) The extent and reliability of test knowledge; and (9) Both professional and public resistance to small numbers of clones.

Zygotic offspring (including vegetatively multiplied propagules) may be deployed either as families (family forestry) or as orchard-run mixtures (classical tree-improvement). For the zygotic offspring of either cp or op seed-orchards, compared to deployed clones, (1) risk to a random genotype will be similar although not identical; (2) if planting density is greater, more loss will be acceptable; (3) because recombination produces a central tendency, overall diversity will be less although greater extremes will occur; (4) gain will generally be less; (5) average stability of the recombinant zygotic propagules will be less than that of clones selected for stability in either WIMP or MOMS configurations; (6) because of within-clone uniformity, rotation times may be slightly shorter with clones in MOMS but similar in WIMPs; (7) management comprehension and efficiencies are much reduced; (8) clonal maturation will erode the reliability of clonal tests while pollen changes or uncertainty will erode cp and op test reliability; and (9) professional public resistance may be somewhat less.

BREEDING FOR CLONAL MIXTURES

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Since no resistances are absolute, nor can safety be assured by increasing the number of clones. Serial breeding for resistance can only lead to arms races with rapidly evolving pests, and to epidemics when virulence evolves. An alternative is to induce a genetic dynamic within pathogen/pest populations that forces non-epidemic behavior. One way to do this is to use clonal mixtures with widely different resistances that require such wide pest adaptations that generalist pests are less fit than specialists. By breeding multiple populations for differences, and using clonal mixtures from them, super-pests may never evolve. Alternative deployment strategies are possible. Therefore, while increasing the number of random clones may not increase security, increasing differences among clones could.

TIME TO FAILURE IN CLONAL POPULATIONS OF FOREST TREES

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The appropriate number of clones to deploy in clonal plantations is a major concern of managers involved with clonal forestry. Although there are a number of characteristics of clonal plantations for which considerations involving numbers of clones are important, a particularly relevant aspect is risk of catastrophic loss due to an unanticipated physical or biotic agent. Even though a clone may not succumb to such an agent for some time after its introduction, it almost assuredly will eventually fall victim to an attack or occurrence of a destructive agent. Analyses of distributions for times to failure for a clone or mixtures of clones thus are useful for evaluating the effect of numbers of clones on the risk of population failure. A model for time to failure is presented and the effect of increasing the numbers of clones in mixtures on the probability of population failure is discussed. Cases are explored showing how increases in numbers of clones can result in either increased or decreased chances for population failure.

ALLOZYME DIVERSITY OF NATURAL STANDS VERSUS SEED ORCHARD LOBLOLLY PINE

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The maintenance of genetic diversity in the breeding population of any commercially valuable species should be a top priority of any breeding program. This may be especially critical for forest tree improvement programs since trees are often reintroduced into highly heterogeneous natural environments. Thus, it is important to determine how much of the native gene pool is maintained in commercial seed orchards. Genetic diversity at 21 polymorphic allozyme loci are compared between 16 natural populations from the eastern range of loblolly pine (*Pinus taeda*) and two loblolly pine seed orchards. Of the 21 loci 19 (90.4%) are polymorphic in each of the two orchards. Relative to the natural populations 83.6% and 88.2% of the genetic diversity and 62.3% and 60.9% of the 69 alleles observed in the natural populations were maintained in the two orchards. Every allele that was missing from the orchards had an average frequency across the 16 natural populations of less than 10%. The majority (66%) of the absent alleles had mean frequencies of less than 1% in the eastern range of loblolly pine.

BIOLOGY TO POLICY: CASTING PEARLS TO SWINE

J.V. Hood

Ontario Ministry of Natural Resources

Increased international exchange of forest tree seeds and cuttings led to, in the 1960's-70's, the first "official" guidelines for movement and/or trade. The growing use of vegetative propagules with tree species other than Poplars induced Sweden and Germany to put into place regulations governing the production and trade of clonal material in 1982 and '85 respectively. Denmark, Belgium, New Zealand, Canada and Ontario have since followed suit with either policy, guidelines, a proposal or a discussion paper. Pertinent details of these efforts, primarily as they pertain to clonal forestry, are compared and contrasted.

ABSTRACTS OF
POSTER EXHIBITS

VARIABILITÉ GÉNÉTIQUE DE POPULATIONS D'ÉPINETTE BLANCHE (*PICEA GLAUCA* (MOENCH)) INTÉGRÉES DANS LE PROGRAMME D'AMÉLIORATION DU QUÉBEC

Mireille Desponts, Ariane Plourde, Jean Beaulieu et Gaétan Daoust

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La préservation du patrimoine génétique préoccupe grandement les responsables des programmes d'amélioration des essences forestières. C'est dans cette optique qu'on a vérifié si les sélections qu'impliquent ces programmes ont entraîné une baisse de la variabilité chez l'épinette blanche au Québec. La structure et la variabilité génétique de 2 populations naturelles ont été comparées à celles observées dans 3 provenances, ainsi qu'à un groupe d'individus du croisement diallèle. Les résultats obtenus par l'analyse électrophorétique de 7 systèmes enzymatiques indiquent globalement le maintien de la variabilité parmi les provenances. Malgré une réduction importante de l'effectif, les individus impliqués dans la plan de croisement diallèle montrent des taux d'hétérozygotie et de polymorphisme très élevés suggérant un effet d'hétérose.

DIVERSITY OF THE MITOCHONDRIAL GENOME OF *LARIX*

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and

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Despite their ecological and commercial importance, conifer mitochondrial genome organization, complexity, and diversity is not well known. As descendants of some of the most primitive land plants, conifers have unique physiology and genetics. We have isolated total genomic DNA from several *Larix* species to examine the diversity of the mitochondrial genome, using hybridization with wheat mitochondrial gene probes for restriction fragment length polymorphism (RFLP) analysis. Our results indicate that several *Larix* species can be differentiated by specific RFLP's when hybridized with a wheat mitochondrial gene probe. Wheat mitochondrial gene probes are also being used in heterologous hybridization experiments to study the complexity of *Larix leptolepis*

mitochondrial genes and to evaluate the effect of *in vitro* embryogenic cell culture on individual mitochondrial gene structure and organization.

BIOCHEMICAL MARKERS AS PROBES IN SCREENING BIODIVERSITY IN WILLOW (*SALIX* L.) INTENSIVE FORESTRY

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As the potential for short rotation willow plantations is increasing, both the intensity of the culture and its dependency on clonal stock impose questions regarding the maintenance of genetic biodiversity in *Salix*. One of the most efficient ways of investigating and studying biodiversity is the use of biochemical markers to characterize species, populations and individuals. We report the development of 27 enzyme systems for *Salix*, which encode for at least 50 isoenzymic genes that can be used as markers. Optimal electrophoretic techniques, source tissues for enzymes, gel and electrode buffers, starch compositions, running conditions and staining procedures are presented. The validity of enzyme markers in the assessment and evaluation of biodiversity is discussed.

CHLOROPLAST DNA POLYMORPHISM IN SOME TREE FORM WILLOWS (SALIX) DETECTED BY DIGOXIGENIN LABELED NONISOTOPIC PROBES

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Chloroplast DNA (cpDNA) fragment polymorphism in some willow ssp. was visualized by digoxigenin labeled nonradioactive probes. Some critical parameters have been determined that are important for optimizing the sensitivity and avoiding non specific banding background of digoxigenin system. Compared to ^{32}P labeled probe, digoxigenin labeled DNA was more efficient in detecting chloroplast DNA in *Salix*. Interspecific cpDNA polymorphism were evident between diploid species and tetraploid species. RFLPs were identified that differentiate diploids and tetraploids. Intraspecific conservation of RFLPs was confirmed by examining trees from different sites across the species natural range. A mislabeled accession of *S. alba* L. was delineated based on its unique variants detected by different combinations of enzyme digestion and probe hybridization. *S. alba* L. and *S. pentandra* L. share the same chloroplast genome which implies a same progenitor involved in the process of their polyploidization.

DNA POLYMORPHISM IN *SALIX* AMPLIFIED BY PCR WITH ARBITRARY PRIMERS

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Newly developed, random amplified polymorphic DNA (RAPD) markers are well suited for genetic mapping, for DNA fingerprinting and for plant breeding applications. The present study demonstrates that these RAPD markers are also useful for the study of species relationships in *Salix*. DNAs from twelve willow species were amplified by polymerise chain reaction with seven arbitrary primers. Polymorphism were evident among species. Species kinship was inferred based on RAPD polymorphisms.

MULTILOCUS STRUCTURE IN *PINUS CONTORTA*

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We studied non-random associations (Gametic disequilibria, GD) between alleles at different allozyme loci for 66 populations from three sub-species, and elucidated the contribution of GD to development of multilocus structure in *Pinus contorta*. For each population, the distribution of number of heterozygous loci in two randomly chosen gametes was established and compared with the expectation without GD. The total and average variances over populations were partitioned into single-locus and two-locus effects of population structure. GD were important and accounted for a major part of structuring in *P. contorta*.

CLIMATES OF ONTARIO AND GENETIC VARIATION

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The principle guiding the choice of seed source for successful establishment of artificially regenerated forests is simple; match the environment of seed origin to that of the deployment environment. In areas where environmental gradients are steep, such as boreal Ontario, movement of seed must be carefully controlled to ensure the use of well-adapted stock. The Ontario Ministry of Natural Resources and Environment Canada are working together to update information on climatic gradients in Ontario. This information is to be used in the management of seed collection and deployment in Ontario.

SITKA SPRUCE IN A CHANGED CLIMATE

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Science and Sustainable Development Directorate
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This poster is based on previously published data on several provenances of Sitka spruce growing in western Newfoundland. Sitka spruce survived and grew poorly compared to local black spruce, but in plantations with the best survival and growth, the tallest tree in each replicate was usually a Sitka spruce, and the tree-to-tree variation in height of Sitka spruce was much greater than black spruce. The climates of the seed origin and plantation are compared. The difference in mean annual temperature between the seed origin and planting site is about 2.5°C, well within the ranges predicted by climate models although the temperature change is in the opposite direction.

Trees have reacted strongly to the seed transfer, over half of them have died, many more have survived as 'cabbages' barely reaching a height o 50 cm in 25 years. A small proportion, probably about 5%, however, grew rapidly and are tolerant to local climate, insect and disease conditions as the native black spruce. The data demonstrate that conifers have an extremely variable genotype as befits a group of organisms with a long geological past and wide distribution. Conifers may be very adaptable to future changes in climate and the indications are that a land race is developing in western Newfoundland in response to what is in effect a changed climate. This may represent one view of our forests in the future.

ADAPTIVE VARIATION AMONG JACK PINE POPULATIONS NORTH OF LAKE SUPERIOR

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An intensive short-term provenance study was used to determine the patterns of adaptive variation displayed by jack pine (*Pinus banksiana* Lamb.) throughout a portion of its range in north-central Ontario. Seed from 64 populations was planted in common gardens tests in three environments and ten traits relating to phenology and growth rate were examined. Seed origin was a significant source of variation for most individual seedling traits in all trials. The first principal component was associated with growth potential, while the second was more closely related to drought resistance. Multiple regression analysis of principal component scores indicated that latitude, longitude, total precipitation, and maximum temperature explained some of the variation seen among populations.

EFFECT OF TREE SPACING, CONE STORAGE, YEAR OF COLLECTION, AND PRECHILLING ON GERMINATION OF *PICEA GLAUCA* (MOENCH)VOSS SEED

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Cones were collected late August in 1984 and 1988 from 13 open-pollinated white spruce trees growing in a demonstration seed production area at the Petawawa National Forestry Institute. Trees were at spacings of 1.2, 2.4, or 4.9 m. Seeds were extracted from cones after 2 or 6 weeks of storage. For each of the 2- and 6-week cone storage periods, four 100-seed samples were prechilled and four others were non-prechilled. The objective of this study was to evaluate the effect of cone storage and prechilling on seed germination for white spruce from cones collected at the time of seed dissemination from individual trees in two different years.

Seed were more mature at collection time in 1988 than in 1984 as evidenced by the germination results. Non-prechilled seeds from cones stored for two weeks averaged 30 and 61% germination in 1984 and 1988, respectively. Seeds from cones stored for 6 weeks in 1984 matured during the storage (up to 60% germination) whereas those in 1988 did not. Prechilling of seed after two weeks of storage increased germination percentage from 30 to 60%, and from 61 to 87% in 1984 and 1988, respectively. This was an indication that seed dormancy was present in both years. Prechilling of seed after 6 weeks of storage increased germination from 60 to 95% and 64 to 89% in 1984 and 1988, respectively. Thus, dormancy remained high after 6 weeks of storage. Analyses of variance indicated that all factors (year of collection, cone storage, seed treatment, tree spacing, and individual trees) were significant in explaining the percentage of germination. However, tree spacing explained little of the variation in the data (0.2%); seed treatment, cone storage, individual trees, year of collection, and the error term explained 39, 15, 16, 8 and 22%, respectively, of the variability in germination percentage.

EFFECT OF SITE AND FAMILY ON BLACK SPRUCE (*PICEA MARIANA* (MILL. B.S.P.)) SEED GERMINATION AND CONE MORPHOMETRIC CHARACTERISTICS

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Cones were collected from each of three trees in each of nine families located in two black spruce (*Picea mariana* (Mill.) B.S.P.) seedling seed orchards in early September 1990. Trees in the Three Brooks and Second Falls orchards, located in northwestern New Brunswick, were used for the collection. The objectives of the study were to determine: i) the effect of site and family on cone morphometric characteristics such as cone length, full-seed yield, total seed yield, and total number of fertile scales; and ii) the effect of site, family, and trees within family on seed germination and rate of germination. Four replicates of 50 seeds per tree for each family and for each site were used to evaluate seed germination percentage and germination rate (Czabator Peak Value = PV).

Analyses of variance of germination percentage and PV indicated that site, family, and individual trees within each family, as well as the interaction site*family, were all significant. Site had the highest F-value with family second and trees within family last. Cones from the Three Brooks orchard were the longest (36 vs 31 mm), had the most fertile scales (46 vs 42) and yielded the most seed (full and empty; 53 vs 47); however, seed from the Three Brooks orchard had the lowest germination percentage and PV. Among the various cone characteristics studied, only cone length differed among families.

This study indicates that the location of an orchard may play a major role in seed germination percentage and germination rate. In addition, cone size may not be a good indicator of seed quality.

VARIATION MORPHOMÉTRIQUE DES CONES DE PINS BLANCS AU QUÉBEC

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Les résultats d'une étude de la variation morphométrique des cônes de pins blancs (*Pinus strobus* L.) sont présentés. Le but est de vérifier l'existence de divergences régionales.

Dix populations originant de quatre régions du Québec ont été échantillonnées. Huit caractéristiques ont été mesurées sur les cônes. Des techniques d'analyse multidimensionnelle ont été utilisées.

Les quatres régions diffèrent entre elles. Celle d'Anticosti est la plus divergente du groupe, suivie de celle d'Abitibi. Les régions St-Laurent et Outaouais ne sont pas semblables bien que les conditions pédoclimatiques générales soient similaires.

Il est proposé que ces différences soient le reflet d'une adaptation à des conditions locales particulières. La répartition spatiale des populations peut aussi jouer un rôle.

MORPHOMETRIC VARIATION IN WHITE PINE CONES FROM QUEBEC

Results from a study of the morphometrics of eastern white pine (*Pinus strobus* L.) cones are presented. The aim was to identify regional differences.

Ten populations from four regions in Québec were sampled in 1989. Eight cone traits were measured. Multivariate analyses were used in order to identify trends.

The four regions samples are significantly different. Anticosti island population is the most divergent one followed by the Abitibi population. The St-Lawrence and Ottawa river regions are different despite the fact that their climate and ecological conditions are relatively similar.

We believe that the differences are mainly due to adaptation to local conditions, but spatial distribution may also be involved.

INDUCTION FLORALE CHEZ *PICEA GLAUCA* ET *P. ABIES*

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Afin d'accélérer la production de semences forestières et la réalisation de notre programme de croisements dirigés chez *Picea glauca* (Moench) Voss et *P. abies* (L.) Karst., des essais de stimulation de la floraison ont été réalisés en 1990 dans nos parcs d'hybridation. Vingt clones de *P. glauca* âgés de 10 à 13 ans et 15 clones de *P. abies* âgés de 7 ans ont reçu divers traitements. Les traitements 1 et 2 consistaient à injecter 100 mg de $AG_{4/7}$ seul ou avec 10 mg de ANA (demi-dose pour *P. abies*). Le traitement témoin ne contenait que le l'alcool utilisé comme solvant pour les autres traitements. Les données recueillies au printemps 1991, soit le nombre de strobiles femelles et mâles par verticille ont été analysées. Nous présenterons les résultats et les conclusions de cette expérience.

PHENOLOGY OF NATIVE AND EXOTIC *LARIX* MILL. SPECIES IN NEW BRUNSWICK

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Several provenances of eight species of *Larix* Mill. were planted in the UNB Larch Arboretum in 1988. This provides a unique opportunity to study phenological responses of each provenance to the conditions (temperature and photoperiod) at a common site. The responses, such as, time of growth initiation, occurrence of late shoots and time of growth cessation, will give an indication of genetic differentiation within and among species, and adaptation to the local environment.

BRANCH BENDING ON 8 YEAR OLD EUROPEAN AND JAPANESE LARCH GRAFTS INDUCES MALE FLOWERING

Cathy Nielsen and Hilary Veen

Fast Growing Forests
Ontario Ministry of Natural Resources
Brockville, Ontario

Lower branches of European larch grafts were bent downwards in early spring of 1989 and kept in position until October of the same year. The following spring numbers of male and female cones were analyzed. Branch bending had a highly significant effect on male flower production ($P>0.0001$), but did not effect female flowering. The same treatment applied to Japanese larch in 1990 produced similar results. This treatment can be used operationally to obtain pollen from selected clones.

POLLEN CONTAMINATION IN THE ISLAND LAKE SEED ORCHARD

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Our field site is at the Island Lake Tree Improvement Area (ILTIA), Chapleau, N. Ont. We began work during the 1990 pollination season and continued in 1991. Our work was preceded in 1989 by the pollen contamination study of Dr. R.H. Ho (OFRI-OMNR).

Objectives:

- To study the aerobiophysics of pollen dispersal, i.e. the source of pollen, its dispersal characteristics and its mode of deposition
- To modify models of particle dispersal to simulate pollen flow in seed orchards
- To test and modify the model for use by seed orchard managers and designers to reduce pollen contamination

Methods:

- We look at the source of pollen in three different ways: we are testing the feasibility of attempting to determine the number of pollen shed per tree/unit area; we look at the 'effective' source strength of contaminant pollen at the upwind edge of the orchard; and we release tracer particles upwind of the orchard (pollens exotic to Chapleau). We are also looking at the meteorological "trigger" mechanisms which initiate pollen dispersal (e.g. temperature, humidity, etc.)
- The dispersal of pollen is traced by: measuring wind flow patterns within the orchard using anemometers; setting sticky slides within the orchard to monitor pollen deposition; and using the tracer particles to show dispersal directions
- The deposition of pollen is measured on the ground, on branches and on seed cones to determine the overall pollen budget

- In 1991 we have initiated a set of studies to look at diurnal and nocturnal variation of pollen flow.

Summary of Results:

- Pollination is a short-time process (e.g. fig. 1) which is climatically controlled and predictable
- Preliminary results from 1991 indicate rain to be an important factor in pollen deposition (including deposition to seed cones)
- Results so far indicate the distance of pollen dispersal into the seed orchard and thus give an indication of management techniques useful to reduce contamination (e.g. buffer zones; fig. 2)

DEVELOPMENT OF HYBRID POPLAR CLONES IN EASTERN ONTARIO

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Since 1976, approximately 2,260 hectares of hybrid poplar have been planted in eastern Ontario through a cooperative program between the Ontario Ministry of Natural Resources and Domtar Incorporated. New clones are continually required for the annual planting program. Interspecific breeding produces several thousand seedlings annually and multiple-stage clonal selection is used to select new clones for planting. Nursery tests identify clones which are resistant to *Septoria* canker, have good rooting ability, and photoperiodic adaption, and fast early growth. Promising clones are tested on field sites to identify "plastic" clones. Top-ranking "plastic" clones are planted in blocks to obtain yield estimates. Finally, new clones for plantation establishment are identified.

DEVELOPMENT AND EVALUATION OF HIGH YIELDING WILLOWS FOR ENERGY PRODUCTION

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Forest Genetics Laboratory
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Genetic and breeding research, aimed at the development of high yielding willow clones by selection and hybridization of North American species, was undertaken by the Forest Genetics Laboratory, University of Toronto.

A series of four clonal screening trials containing intra- and interspecific crosses of *Salix* species, was established in 1986 and 1987. The purpose of these trials was to provide information for the screening of superior clones (based on biomass production, growth habit and disease resistance).

In 1990, all trials were assessed for biomass production. The results of this harvest indicate that the yields produced by the best of the North American clones equal and often surpass those produced by willows in Swedish and United Kingdom programmes (where willows have been bred for several hundred years). Since these clones represent a first attempt at selection and breeding, the prospects for improving North American willow are excellent.

JUVENILE GENETIC EVALUATION OF LODGEPOLE PINE AND ITS IMPLICATIONS IN EARLY SELECTION

Xiaming Wu and Francis C. Yeh

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University of Alberta

A retrospective study was initiated for lodgepole pine (*Pinus contorta* spp. *latifolia*). Genetic performance of 121 open-pollinated families was assessed for two growing seasons in the greenhouse. Genetic parameters (heritability and genetic correlation) for growth, bud, branch, and biomass characters were estimated. The potential of predicting mature performance using single and/or composite juvenile characters is presented.

TECHNOLOGY DEVELOPMENT FOR AN ACCELERATED BREEDING PROGRAM

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Tree improvement efforts in Eastern Ontario are concentrated primarily on white pine, Norway spruce and the larches. Technology development efforts at the G. Howard Ferguson Forest Station in Kemptville, Ontario, are focused on accelerating the breeding and testing process for each of these species. Fall grafting is utilized for white pine plus trees that are difficult to access and to supplement the winter grafting program. Growing grafts under environmentally controlled conditions and applying compressed growth cycles increases growth and reduces the time to onset of flowering. Flower induction treatments are applied to obtain early and abundant flowering once the grafts have reached a size of 1.0 to 1.5 m in height so that controlled crosses can be carried out as soon as possible. Early progeny testing in the form of nursery screening trials allows early roguing of the production population and promotes the selection of superior genotypes at the earliest possible time. Vegetative propagation facilitates the early reproduction of superior material in a shorter time period as compared to conventional seed orchards.

GENETIC RESISTANCE TO THE WHITE PINE WEEVIL IN SITKA SPRUCE

Cheng C. Ying

Forest Science Research Branch
B.C. Ministry of Forests

Fifteen-year records of weevil attacks in Sitka spruce provenance trials revealed large differences among provenances in percent of trees attacked and number of attacks per tree. This provenance variation in weevil attack was repeated in a clonal test suggesting a genetic basis in weevil resistance. On the average, provenances from the high weevil hazard zone and also those from the hybridization (white Sitka spruce) zone showed a high level of resistance to weevil attack. Two provenances, Haney and Big Qualicum, which showed high resistance to weevil and were also fast growing are recommended as seed sources for reforestation at sites in the high weevil hazard zone.

PART II

ACTIVITY REPORTS FROM ACTIVE CTIA MEMBERS

FOREST GENETICS, NEWFOUNDLAND AND LABRADOR REGION

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Keywords: Seed production, gene pool preservation, reproductive success, seed zones, provenance, balsam woolly adelgid

Following prolonged, severe, spruce budworm infestations throughout the 1970's and 1980's, seed procurement became an important concern for Newfoundland's artificial regeneration program. During the bumper crop of 1988, several studies relating to early cone collection, reproductive success, and cone and seed pests were initiated for black and white spruce on the Island and in Labrador. Most of these studies will be completed this year.

Red and white pine were once prominent features of the Island's landscape but they are now quite rare. Ecological studies on reproductive success, natural self-pollination, genetic variation, and regeneration in red pine were initiated to investigate the apparent decline of red pine as a naturally occurring species on the Island. Efforts to preserve the Island's small red pine and white pine gene pools are underway.

Newfoundland's climatic and ecological diversity suggest that a delineation of seed zones may be important for the Island. Since we lack suitable regional provenance tests for our commercially important species, we have established a genetic test that uses a native willow species, *Salix discolor* Muhl., as a biological indicator to assess the influence of the Island's ecological regions on genetic variation and structure. We are also selecting clones for wind break establishment in conifer seed orchards and progeny tests, and for use as a nurse crop in the establishment of conifers on Newfoundland's coastal barrens.

We continue to monitor range-wide provenance tests of black spruce and tamarack to assess adaptation of local and exotic seed sources to conditions on the Island.

The balsam woolly adelgid is now the most serious economic pest of young, managed forest stands on the Island and no effective chemical or biological control measures are available. Observations suggest the existence of genetic variation in the susceptibility of fir. In 1991 we will initiate research with the following objectives: (i) to obtain evidence of a genetic basis for resistance through artificial infestation studies on open-pollinated progeny; (ii) to determine the effect of infestation on the reproductive success of fir; (iii) to characterize the genetic or clonal structure of the adelgid - a putative obligate parthenogen; (iv) to establish the chemical basis for resistance or susceptibility in fir; and (v) to develop silvicultural guidelines for the management of this pest.

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NEW DIRECTIONS IN TREE IMPROVEMENT IN NEWFOUNDLAND AND LABRADOR

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Keywords: seed orchards, vegetative propagation, biotechnology

During 1990 and 1991, a comprehensive review of the province's tree improvement programme was conducted. A new five-year plan has been approved since redefinition of priorities.

The first priority will be **completion of all first-generation seed orchards.** Basil Corbett, an expert grafter from PNFI, spent a week in Newfoundland training staff in all aspects of grafting, from the proper sharpening of grafting knives to overwintering of grafted trees in the nursery. The number of grafts will be increased three- to four-fold for the next four years, with the objective of completing all first-generation orchards and breeding gardens by 1985, with the possible exception of jack pine. That species is an exotic in this province, the planting of which is primarily intended for Labrador. The Department plans to wait until early results from provenance trials and progeny tests, established in 1989 and 1990, are available before planting jack pine orchards.

One of our main new directions will be **vegetative propagation of seedlings**.As part of the review, Dr. Tim Boyle, then of PNFI, visited Newfoundland in October, 1990. He was impressed by the performance of some of the Quebec black spruce plus tree families now being progeny-tested in Newfoundland.He recommended that the Province vegetatively propagate seedlings of those families for use as improved planting stock. It is planned to construct facilities for this purpose in 1991, and begin large-scale vegetative propagation in 1992. The programme will start with the Quebec black spruce, and later expand to other species and strains.

Biotechnology is an area in which we plan to keep up to date on pertinent developments. However, no major provincial undertakings in this area are scheduled, although a Department proposal for establishing an ethanol industry in Newfoundland based upon speckled alder has been turned over to the Economic Recovery Commission for consideration. I have represented the Province at three BIOFOR meetings, and was one of only two provincial governments actually at the inaugural BIOTIA meeting in Montreal in March, 1991. I have had input into national policy-making committees and surveys in this area on several occasions in the past five years. It is the Province's policy to be prepared at all times to seize upon any opportunity to enhance or accelerate our tree improvement programme, or any forestry programme for that matter, by means of biotechnology.

Inter-agency co-operation will be another major thrust of the new plan. I have already had many beneficial contacts and co-operative efforts with other provinces and agencies, especially Quebec's Ministère de l'Energie et des Ressources,PNFI, NBTIC, OMNR, and the various regional Forest Research Centres operated by ForCan. So far, though, I have only scratched the surface of this vast wealth of information and materials. Henceforth, keeping abreast of what is being done elsewhere will be a major activity in its own right, not just an incidental activity in conjunction with other projects. A special emphasis will be placed on joint efforts with the Newfoundland Forest Research Centre.

The province's tree improvement strategy, published in 1986, will not be drastically changed by the new directions. Most on-going projects, such as exotic species trials, will still be continued to completion, but emphasis will be placed on establishing first-generation seed orchards as quickly as possible.

POLLEN MONITORING AND SEED RELATED STUDIES AT THE UNIVERSITÉ DE MONCTON

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Keywords: *Picea mariana, Picea glauca,* pollen monitoring, cone storage, seed germination, bisexuality, proliferation

INTRODUCTION

This report summarizes research completed at the Université de Moncton during the past two years, namely on i) pollen monitoring, ii) cone storage and seed prechilling effects on white spruce (*Picea glauca* (Moench) Voss) seed germination, iii) site and family effects on black spruce (*Picea mariana* (Mill.) B.S.P.) seed germination, iv) presence and description of bisexuality and proliferation in black spruce, and v) ten-year height growth for black spruce families.

POLLEN MONITORING STUDIES

Pollen monitoring studies conducted in 1987 and 1988 in two black spruce seedling seed orchards (Caron 1987; Caron and Serry 1988) were repeated in 1989 (Caron 1989). Similarly pollen monitoring in a white spruce orchard and from a larch (*Larix laricina* (Du Roi) K. Koch) stand was repeated in 1989 (Caron 1989). Monitoring of the orchards should be carried out every few years to verify changes in pollen contamination levels associated with increased orchard pollen production.

Pollen monitoring in a white spruce clonal orchard and a black spruce seedling seed orchard was initiated in 1991 with the Ministry of Forests at St-Elzéar, Quebec. The objective is to verify the level and source of contamination as an aid to selection of proper corrective measures to limit pollen contamination from unselected sources.

SEED GERMINATION STUDIES

Cone storage for up to 6 weeks and seed prechilling were found in a 1984 study to be important in promoting germination percentage and rate of germination in white spruce (Caron *et al*. 1988, 1990). Storage of cones collected in 1988 for 2, 4, 6, 10, and 14 weeks indicated that, in contrast to 1984, storage was not important in promoting seed maturity, and hence did not increase seed germination percentage and germination rate (Caron *et al.* 1991)

The effect of site and family on cone morphometric characteristics and on seed germination and rate of germination was investigated for black spruce families in two different orchards in northwestern New Brunswick (Nadeau 1991; Nadeau and Caron 1991). This study indicated that the location of an orchard may play a major role on seed germination percentage and germination rate. In addition, cone size may not be a good indicator of seed quality.

BISEXUALITY AND PROLIFERATION IN BLACK SPRUCE

Bisexuality (bisporangiate strobili) can be detected infrequently in young trees (Caron and Powell 1990). Most often, microsporophylls are located proximally and bracts distally (Caron and Powell 1990) but recent monitoring in young orchards indicated that the reverse arrangement (bracts proximal and microsporophylls distal) is also possible.

Seed-cone proliferation (a combination of needles and bracts on the same structure) and pollen-cone proliferation (a combination of microsporophylls and needles on the same structure) are fairly common in young black spruce trees (Caron and Powell 1991). In that study, the number and kind of axial elements were compared along each of the various proliferated forms, seed cones, and pollen cones.

POPULATION GENETIC STUDY

Ten-year height growth of 77 half-sib black spruce families located in northwestern New Brunswick indicated that all factors (location of the family tests, replication , family) and their interactions were significant (Montreuil 1991). Location of the tests, replication, family, the interactions replication x family and location x family, and the error term explained 8, 5, 5, 4, 3, and 75% of the variability in the data. Narrow-sense heritability was 0.22.

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FOREST GENETICS RESEARCH AT FORESTRY CANADA MARITIMES REGION

Y.S. Park, J.M. Bonga, D.P. Fowler, C.H.A. Little,
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The Forest Genetics project at Forestry Canada - Maritimes Region consists of three integral parts: basic research on genetics of important tree species, operational research and technology transfer, and research and development in biotechnology. Accordingly, the objectives of the project are (1) to determine the amount of genetic improvement within promising genera and to further scientific knowledge of tree species, (2) to provide resource managers in the Region with information and breeding material necessary to attain realistic genetic improvement in applied tree improvement programs through technology transfer, and (3) to develop biotechnical procedures and to evaluate the potential of biotechnology for tree breeding.

During 1989 - 1990, this project was reviewed internally and reorganized in accordance with the Forestry Canada - Maritimes Region's Strategic Plan. Fifteen strategic objectives, which would be implemented in the next 5 years, were identified. Under the Strategic Plan, several new approaches to tree improvement, e.g., clonal breeding strategy and biotechnology, have been given emphasis, while several older provenance and inbreeding experiments will be completed over the next five years.

The position vacated since the retirement of Dr. D.P. Fowler was staffed by Dr. J.A. Loo-Dinkins. Dr. Loo-Dinkins, formerly a Research Associate at the University of British Columbia and a consulting geneticist for B.C. Ministry of Forests, will be involved in studies concerning genetic adaptation of tree species under environmental and climate change. Dr. D.P. Fowler continues to contribute to the project under a one-third time contract. In addition, Dr. C.H.A. Little, a tree physiologist whose research partly involves genetic engineering, joined this project. Mr. R.F. Smith has taken an educational leave to pursue a Ph.D. degree at the University of Maine. Dr. Y.S. Park assumed the responsibilities of project leader in 1989.

RESEARCH ON GENETICS OF IMPORTANT TREE SPECIES

"Species and provenance trials" and "population genetic studies" are the components of the basic research on genetics of important tree species. Most of the provenance and species trials, except for the most recent series of trials with black spruce and tamarack, will be completed after a final assessment. A range-wide provenance test of tamarack involving 65 provenances established at 9 different locations in the Maritimes Region was measured for 5-year height and quality characters. Also, a range-wide provenance test of black spruce was measured for 16-year performance at 10 different locations in the Region. Similarly, several series of Norway spruce provenance trials were measured for final assessment.

Emphasis in population genetic studies has shifted over the past several years from natural populations to first generation breeding populations. In anticipation of the commercial implementation of clonal forestry practices, our genetic testing procedures were modified to include clonally replicated trees, which allows estimation of genetic variances with greater precision. During 1989 - 1990, a series of black spruce clonal experiments, derived from a disconnected diallel cross design and subsequent cloning by serial rooted cuttings, was established at four locations in the Region including a short-term nursery test. The experiment involves 360 clones with 60 ramets per clone for a total of over 21,000 stecklings. Similarly, in January 1990, a white spruce clonal experiment was initiated, and the first-cycle stecklings were produced with a 100% rooting for nearly all the clones. The material used in this experiment was derived from disconnected diallel crosses of first generation selections. A clonally replicated experiment of tamarack, involving 240 clones, established at 2 locations in the Region was measured for 9-year height, DBH, stem straightness, number of sylleptic branches, and other characters.

Based on earlier research on hybridization of *Picea* and *Larix*, work on developing short- rotation crop trees has begun. An objective of this research is to mitigate the serious impact of projected climate change in the forestry sector by providing shorter rotation trees and, therefore, increasing the flexibility of reforestation programs. The research includes genetic testing under various climatic and environmental conditions, vegetative propagation via somatic embryogenesis, clonal deployment strategies, and analysis of RFLP and other molecular markers for early selection.

OPERATIONAL RESEARCH AND TECHNOLOGY TRANSFER

Cooperative Tree Improvement

Forestry Canada - Maritimes Region provides technical coordination and direction in the operation of the New Brunswick Tree Improvement Council (NBTIC). In 1990, NBTIC completed its 14th year of operation. Member agencies are providing funding for a full time data analyst to deal with the large volume of data from family tests. Mr. D.G. Steeves has been hired for the position. Program emphasis has shifted to selecting, breeding, and testing second generation black spruce and jack pine as well as breeding and testing first generation white spruce and tamarack. The first, second generation clonal seed orchards of black spruce and jack pine were planted.

Second generation selections of black spruce and jack pine are being made in family tests. Top performing black spruce families are identified based on analysis of 10-year data and subsequently the six tallest trees per family are picked for evaluation in the field for stem straightness and crown form. To obtain a base population of 400 selections, the best tree in about one-third of the tested families is selected. For jack pine, selections are based on seven-year measurements and the six tallest trees per top ranking family are evaluated for straightness, branch angle, and branch diameter. One tree is selected from each of the top performing 50% of families to form a 400 tree breeding population.

Seed production from seed orchards has increased steadily. Jack pine seedling seed orchards have been producing sufficient quantities of seeds for about three years to satisfy annual planting requirements. Production from the black spruce seedling seed orchard was phenomenal in 1990 with over 140 million seed collected from 40 ha of orchard. The oldest orchards are 12 years old and most producing orchards have been rogued once. Seed yields from white spruce clonal orchards have also been increasing, but production from tamarack clonal orchards has been consistently poor.

A genetic gain of 7.6% in volume was estimated from 10-year jack pine family test data while holding stem straightness constant. Realized gain tests for black spruce and jack pine will be established to obtain more accurate determination of gains using genetically improved seeds.

CONE AND SEED / SEED ORCHARD MANAGEMENT

Staff from both Forest Genetics and the Forest Disease and Insect Survey continue to provide assistance to orchard managers in the Region through technology transfer and by conducting operational, problem-oriented research trials.

Cooperative cone induction trials using combinations of fertilizers and $GA_{4/7}$ in black, white and red spruce seed orchards were continued, focusing on increasing both male and female cone production. Results indicated that GA alone only increased female flower production, whereas fertilizer plus GA increased both male and female cones.

Third-year results from topping trials in black spruce seedling seed orchards were obtained. Removing 50% (1.5 years growth) for two consecutive years significantly reduced tree height without reducing cone production. With respect to reducing height growth, late fall topping (September and October) was preferable to mid-summer.

RESEARCH AND DEVELOPMENT IN BIOTECHNOLOGY

Recent advances in biotechnology offer opportunities for improved conifer propagation as well as for genetic engineering. Vegetative propagation or cloning offers substantial advantages over seed propagation since identical copies of superior genotypes can be produced.

During the report period and the next five years, somatic embryogenesis and cryopreservation in white and black spruces will be given major emphasis. Using the material from disconnected diallel crosses of white spruce, factors influencing the production of embryogenic calli are being investigated. Preliminary results indicate that somatic embryogenesis is under strong genetic control as well as control by other abiotic factors. The emblings produced by somatic embryogenesis are being raised in a greenhouse. Subsequently, the fidelity of three propagule types, i.e., seedling, steckling and embling, will be compared.

To bring the somatic embryogenesis technique to an operational level, cooperative research with an industrial partner, J.D. Irving Limited, was initiated using controlled-pollinated black spruce from first generation selections. Many families have successfully produced emblings, and the technique is being refined. In addition, an experiment involving cryopreservation is planned.

Clonal propagation of selected mature conifers by tissue culture has been one of our major goals for many years. Most of our recent work has been carried out with 30-year-old *Larix decidua*, *L. leptolepis* and *L. eurolepis* trees. We can now routinely produce large numbers of adventitious shoots from bud explants of *L. decidua* and *L. eurolepis*. However, to date, only a very small number of these have rooted and survived transfer from the tissue culture medium to soil.

Long-term research on the control of wood production at the molecular level has been continued in cooperation with personnel at the Swedish University of Agricultural

Sciences, Umeå, Sweden and the University of New Brunswick, with two major goals currently in mind. First, to increase wood quantity and quality by identifying key regulatory hormones/enzymes in the cambial region and then manipulating their level/activity using genetic engineering. Second, to determine if the duration of wood production is associated with a change in the nuclear DNA content of cambial cells and then characterize the part of the genome involved in the change.

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TREE IMPROVEMENT AND RELATED STUDIES AT THE UNIVERSITY OF NEW BRUNSWICK

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GENETIC VARIATION AND PARAMETERS, BREEDING STRATEGIES

Results of the cooperative, range-wide black spruce (*Picea mariana* (Mill.) B.S.P.) provenance study at age 15 years from seed revealed that geographic trends for height growth and survival were correlated only in 10 of the 29 test locations, 8 of which were in temperate climates. In most boreal locations, southern provenances grew better in height but survived not as well as northern provenances (Morgenstern and Mullin 1990). The poor performance of the Cape Breton provenances is related to inbreeding (McCurdy 1990).

Graduate student T.J. Mullin completed his analysis of a black spruce progeny test with clonal replicates. For the first time it was shown that epistatic genetic variance may be important for height (Mullin 1990).

Work with other members of the New Brunswick Tree Improvement Council led to the development of a selection index for jack pine (*Pinus banksiana* Lamb.) (Park *et al.* 1989, Adams and Morgenstern 1991). Variation in wood density of 2,400 plus trees of five native species, which had been reported by cooperators in New Brunswick and Nova Scotia, was analysed. Relationships to several stand and geographic parameters were found (Morgenstern *et al.* 1990).

In cooperation with Dr. D.P. Fowler of Forestry Canada and organizations in all three Maritime Provinces larch breeding was continued. This included interspecific hybridization in 1989 and the planting of a larch species and provenance trial in five locations in 1990. Jointly with Dr. K. Carter of the University of Maine the analysis of a clonal test of *Larix laricina* (Du Roi) K. Koch was begun (Morgenstern and Steeves 1990).

CONE PRODUCTION AND CROWN DEVELOPMENT

Distribution of seed cones and pollen cones on young *L. laricina* followed distinct patterns that related to position of origin of the cone (lateral on long shoot or terminal on short shoot) within the crown and along and around the supporting long shoot (Tosh and Powell 1991). Presence of pollen cones borne laterally on long shoots was documented for *Larix leptolepis* (Sieb. & Zucc.) Gord. (Powell and Hancox 1990).

On young *Picea mariana*, bisporangiate cones with varying proportions of pollen-cone and seed-cone parts tended to occupy crown positions between zones of pollen and seed cones (Caron and Powell 1990). Pruning away of 100 and 50% of young *P. mariana* leaders in mid-summer, respectively reduced and did not reduce immediately subsequent seed-cone production (Pardy 1991).

The *Pinus strobus* L. trees scattered (5 stems/ha) in four mature *Picea-Abies* stands in northern New Brunswick produced similar proportions of filled seed (x-ray estimates) whether or not the non-*P. strobus* stand components had been removed at the time of pollination (seed-tree versus closed stand conditions) (Branch 1991).

PHYSIOLOGY AND BIOTECHNOLOGY

The focus continues to be on the regulation of lignification in conifers. E-Coniferin, the primary lignin precursor in conifer cambia, accumulates precociously in relation to the initiation of lignification in springtime (Savidge 1989). Not detectable in seeds, buds, leaves, or bark, coniferin appears to be specific to the cambium but can be found there only during the period of active cambial growth when its levels essentially parallel those of growth (Savidge 1989, 1991a).

Auxin (indol-3-ylacetic acid, IAA), identified by combined gas chromatography-mass spectrometry in more than 30 tree species (Savidge 1990a), appears to be a ubiquitous cambial regulator; however, parallel variation between the cambium's seasonal contents of auxin and coniferin does not occur (Savidge 1991a) making it unlikely that coniferin biosynthesis is under direct auxin regulation. Moreover, no correlation has been found between the cambium's content of sucrose (photosynthate) and coniferin (Savidge 1991a), and the controlling mechanism for coniferin accumulation and, therefore, for lignification remains to be elucidated.

Using explants from merchantable stem regions of *L. laricina* on one fully defined support medium under ideal growth conditions, it has been confirmed over three years that during the dormant period the cambium has a narrow temporal window in which it can reactivate and produce tracheids *in vitro* as normally occurs *in vivo* in springtime. In contrast, these explants are competent for non-xylogenic callus growth at all times (Savidge 1991b).

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J.D. IRVING LTD. - TREE IMPROVEMENT SUMMARY

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Keywords: *Picea mariana*, *P. glauca*, *P. abies*, *Pinus banksiana*, *Larix laricina*, seed orchards, tree breeding, vegetative propagation.

In summary, since 1989, clonal orchard establishment continued with first generations orchards being completed in 1991 and good progress being made in second generation orchards of black spruce and jack pine. Seedling seed orchard roguing continues based on analysis of New Brunswick Tree Improvement Council family tests. Most seed used in nurseries, with exception of Norway spruce, now originates from seed orchards. Tree breeding and progeny testing is proceeding rapidly. Work also continues on vegetative propagation.

SEED ORCHARDS AND SEED PRODUCTION

First generation seed orchards are now complete with the last grafts being planted in the clonal orchard this year for a total area of 61 ha. This includes black spruce (*Picea mariana* (Mill.) B.S.P.), white spruce (*Picea glauca* (Moench) Voss), Norway spruce (*Picea abies* (L.) Karst.), jack pine (*Pinus banksiana* Lamb.) and eastern larch (*Larix laricina* (Du Roi) K. Koch). A total of 33 ha of black spruce and jack pine seedling seed orchards are now coming into seed production with roguing proceeding in several orchards.

All black spruce, jack pine , eastern larch and over 50% of white spruce grown for reforestation in 1991 originates from orchard seed. In 1990, 53 kg of improved seed was processed in the seed extractory at Parkindale Seed Orchard.

Establishment of second generation orchards of black spruce and jack pine is proceeding using selections made in New Brunswick Tree Improvement Council (NBTIC) family tests. To date 3.5 and 3.0 hectares of black spruce and jack pine respectively have been established.

TREE BREEDING AND PROGENY TESTING

Tree breeding is proceeding well at Parkindale Seed Orchard and in the breeding hall at Sussex Tree Nursery. Field test establishment to determine general combining ability for clones at Parkindale is 70 to 80 percent complete for white spruce, black spruce and jack pine but only 30 percent complete for tamarack. Accelerated greenhouse polycross tests are underway in black spruce and jack pine to provide information for assortative pair-mating among clones. These pair-matings will be field planted for future selection

In cooperation with NBTIC, polycross matings are conducted in situ on second generation selections of black spruce and jack pine. By the time grafts of these selections are flowering in the breeding hall, information will be soon available from accelerated tests so that pair-mating can begin.

VEGETATIVE PROPAGATION

Work is continuing on rooted cuttings in the areas of greenhouse culture and hedge plant management. Approximately 50,000 cuttings are outplanted annually. When the first seed from pair-matings among second generation black spruce selections is available, a larger-scale clonal propagation program will likely be pursued.

A joint research project is currently being conducted with Forestry Canada-Maritimes to look into the potential of somatic embryogenesis in black spruce.

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TREE IMPROVEMENT PROGRESS IN NEW BRUNSWICK

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Keywords: Accelerated breeding, cone collection, cross-pollinations, flower induction, progeny tests.

The tree improvement program in N.B. is progressing smoothly. Our efforts continue to be focused on our 4 major reforestation species, black spruce (*Picea mariana* (Mill.) B.S.P.), jack pine (*Pinus banksiana* Lamb.), white spruce (*Picea glauca* (Moench) Voss) and tamarack (*Larix laricina* (Du Roi) K. Koch.). Secondary species for Tree Improvement include balsam fir (*Abies balsamea* (L.) Mill.), Norway spruce (*Picea abies* (L.) Karst.) and white pine (*Pinus strobus* L.).

All first generation selection and seed orchard establishment has been completed for the four major tree species. Second generation selections, cross-pollinations and orchard establishment are well underway. The following report highlights our Tree Improvement activities for the past two years.

PLUS TREE SELECTION

The best individuals selected from the best families in NBTIC (New Brunswick Tree Improvement Council) family tests are being indentified for second generation material. To date, we are 39% complete for black spruce and 59% complete for jack pine. A second generation jack pine orchard will be established in 1991, as well as another 2nd generation black spruce orchard.

TREE BREEDING/TESTING

In 1989 and 1990, black spruce polycrosses done on 2nd generation selections provided sufficient seedlots to grow and outplant the first series of black spruce progeny tests. The polycross seedlots included those from NBTIC members, totalling 80 families. All crosses on jack pine and black spruce are carried out in the NBTIC family tests located province wide. Consequently, springtime at Tree Improvement tends to be tightly scheduled, and quite interesting. A second series of white spruce progeny tests were also established in 1991. Breeding on white spruce is now 35% complete, while tamarack is 16% complete.

In 1991, black spruce and jack pine realized gain tests will be established. These tests will give us a good visual indication of what we are "gaining".

CONE COLLECTION IN SEED ORCHARDS

Both the clonal and seedling orchards have started to produce some seed (Table 1.). The black spruce and jack pine orchards are producing enough seed to meet our annual reforestation requirements with improved seed.

Seed yield from the white spruce and tamarack clonal orchards have been rather dismal, but this year we hope to have improved seed yields by doing supplemental mass pollinations. In 1990, approximately 57 litres of cones were collected from the 9 ha tamarack orchard, yielding less than 1000 full seed.

The cone harvester purchased in 1989 has been used successfully for cone harvesting as well as a multitude of other jobs in the orchard where height and maneuverability are required (i.e. cross-pollinations).

Table 1. Cone collection and seed yield from orchards in 1989 and 1990.

Species	Seed Orchard	Cones (1)		Seed (kg)	
		1989	1990	1989	1990
Black Spruce	Bettsburg	1575	9142	4.9	75.2
SSO	Pokiok	1515	504	6.5	2.6
Jack Pine SSO	Otter Brook	8603	9718	93.1	103.4
White Spruce CSO	Queensbury	243	304	1.8	1.3

ACCELERATED BREEDING PROGRAM

Gibberellin was applied by foliar spray or stem injections to Norway spruce and white spruce grafts for flower induction in July and August of 1990. The combination of accelerating the grafts and treating them with GA 4/7 had no effect on the Norway spruce as, once again, no cones were produced.

Over 70% of the treated white spruce grafts produced cones with an average of 34 female cones per tree for injection and 27 females per tree for foliar. In January, 1991, 20 polycrosses and 4 pair-mates were done in our glass greenhouse. Since then, the cones have been harvested and seed extraction has begun.

Many more of our potted grafts are just reaching a sufficient size (1.5 m) where we can begin treating them with gibberellin.

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TREE IMPROVEMENT PROGRAM

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Keywords: *Picea mariana, Picea glauca, Larix laricina,* seed collections, seed orchards, progeny tests, second generation.

This report summarizes Fraser Inc.'s tree improvement program efforts over the last two years. Establishment of the white spruce clonal orchard is near completion and establishment of a second generation black spruce orchard has started with selections coming from family tests. Control-pollinated progeny test establishment in co-operation with the New Brunswick Tree Improvement Council started in 1989. A tamarack clone bank was completed in 1990. All black spruce production at the nursery now comes from first rogued seedling orchards.

SEEDLING SEED ORCHARDS

First rogueing of the black spruce seedling orchards was continued in 1990 with an additional 7.7 ha of orchard that was established in 1980 and 1981 completed. This brings to 89% the amount of seedling orchard area that has received a first rogueing. Family test measurements planned for the fall of 1991 will be used to start the second round of genetic rogueing in the spring of 1992 in the oldest black spruce orchard (1978).

Seed collections from the black spruce orchards have been outstanding for the past two years. In 1989 we collected 19.1 kg from unrogued orchards and 10.3 kg from once rogued orchards. In 1990 all of the 114.7 kg collected was from once rogued orchards. Since 1989 all black spruce sown at the nursery has come from our orchards and in 1991 all black spruce seed used was from once rogued orchards.

CLONAL SEED ORCHARDS

Establishment of the first generation white spruce clonal orchard is nearing completion. The first cone crop was collected in 1990 and yielded 0.5 kg of seed. Grafting for the second generation black spruce orchard has been ongoing since 1989 and the first portion of the orchard will be established in 1991. Selections come from the best individual of the best family in the NBTIC family tests.

FIELD TESTING

Polycrosses were completed in NBTIC family tests established by Fraser on 38 of 38 black spruce second generation selections selected in 1989-90 to produce progeny test stock. During 1990 and 1991 four tests were established, one black spruce and two white spruce progeny tests and one black spruce realized gain test. Realized gain tests are established to determine if the gain predicted from the use of orchard seed relative to unimproved sources will be achieved. A Scots pine demonstration plantation using seed of Russian origins was also planted. This brings our total established test area to 49.0 ha.

OTHER PROJECTS

The establishment of a tamarack clone bank was completed in 1990. Cooperative projects in relation to orchard management are continuing. Top pruning and cone induction trials in the black spruce orchards, in conjunction with FC-M, are completed or nearly so. Fertilizer applications to the cone induction trials were completed in 1990 and final assessments will be done in 1991. Assessments of the top pruning trial were completed in 1990 and a final report was submitted as a B.Sc.F. thesis at UNB in 1991. Work was initiated in 1990 to survey and monitor our black spruce orchards for cone and seed pests. This is in collaboration with FC-M, the Maritime Provincial FRAC's and other agencies managing orchards to devise an efficient and effective monitoring system for Maritime seed orchards. Work being done with the University of Moncton, Edmundston Campus involves seed- and pollen-cone inventories in the orchards, pollen contamination studies and site and family effects on germination percentage and rate and growth of black spruce orchard seed. Also, assistance and a location was provided to FC-M to establish a black spruce clonal test.

COOPERATIVE TREE IMPROVEMENT IN NOVA SCOTIA

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Keywords: *Picea mariana, P. glauca, P. rubens, P. abies, Pinus strobus*, seed orchards, flower induction, breeding

The Tree Improvement Working Group (TIWG) is the coordinating body for tree improvement in Nova Scotia and has been active since 1977. Founding members include both Federal and Provincial Governments, Bowater Mersey Paper Company Limited, Scott Worldwide Inc., and Stora Forest Industries. In the spring of 1990, J.D. Irving, Limited joined the TIWG. Meetings are held in the spring and fall of each year to review progress and plans, while day-to-day activities are handled by the Department of Lands and Forests. Species of interest include *Picea mariana, P. glauca, P. rubens, P. abies*, and *Pinus strobus*.

ORCHARD ESTABLISHMENT

Expansion of seed orchards has been progressing steadily. First generation orchards should be completed by 1993. Progress to the end of 1990 is as follows:

Species	Location	Type*	Approximate area (ha)	Managing Agency
Black Spruce	East Mines	S	6.4	Scott
	Aldershot	S	7.1	Stora
	Lawrencetown	S	5.0	L & F
White Spruce	Debert	C	4.6	L & F
	East Mines	C	5.5	Scott
	Waterville	C	4.9	Stora
Red Spruce	Melvern Square	C	4.5	Bowater
	Waterville	C	5.3	Stora
	Lawrencetown	C	1.6	L & F
	Debert	C	4.8	L & F
White Pine	Debert	C	1.7	L & F
Norway Spruce	East Mines	C	4.6	Scott
	Debert	C	3.6	L & F
	TOTAL		59.6	

* S = Seedlings, C = Clonal (Grafted)

TESTING

In the spring of 1990, about 400 open-pollinated black spruce families were planted in tests totalling close to 25 ha. This completes first generation test establishment for this species. In the spring of 1991, approximately 100 white and 50 red spruce polycross families were outplanted in several locations throughout the province. This marks the beginning of first-generation testing for these species.

BREEDING

Progress in breeding has been hampered by poor natural flower crops. The strategy employed consists of polycrossing to determine GCA, and a series of paired matings from which second generation selections will be derived. Emphasis at this time is on completing polycrosses. As of the end of 1990, polycrossing was 30% complete for white and 12% complete for red spruce. Heavy flowering in 1991 should see significant progress being made in both our polycrossing and paired mating programs for both of these species.

FLOWER INDUCTION

Foliar sprays of $GA_{4/7}$ are being used in soil-based clone banks in an effort to speed the breeding cycle. In 1990, 50 clones each of red and white spruce were treated weekly for 6 (red spruce) or 8 (white spruce) weeks with $GA_{4/7}$ at a concentration of 250 mg/L. The gibberellin applications resulted in 5.3 times as many female flowers in red spruce, and 3.5 times for white. This work will be continuing using both foliar sprays and stem injections.

A trial using $GA_{4/7}$ alone and in conjunction with fertilizer was initiated in a Norway spruce seed orchard. The trees were about 3m tall at the start of the trial. Eight foliar applications of $GA_{4/7}$ at 500 mg/L were used, both alone and in conjunction with a single application of ammonium nitrate (250 g/tree). Female flowering increased almost 17-fold as a result of gibberellin treatments, and over 28-fold when fertilizer was also applied. Fertilization alone had no effect on female flower production. Male production was also higher on GA-treated trees, but less so than for females. This work will be continued, and stem injections incorporated into the experimental design.

RETROSPECTIVE TESTING

A series of retrospective tests of Norway and red spruce were sown in the greenhouse in March of 1991. Plans are to grow a portion of this material in pots in the greenhouse for 2 - 3 years, and to grow a portion in nursery transplant beds. It is hoped that nursery results will correlate well enough with conventional field test results so that accelerated test results can be used to direct our specific crossing program.

AMÉLIORATION DES ARBRES FORESTIERS À LA DIRECTION DE LA RECHERCHE DU MINISTÈRE DES FORÊTS DU QUÉBEC

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AMÉLIORATION DU PIN GRIS (*PINUS BANKSIANA* LAMB.), DU PIN DE MURRAY (*P. CONTORTA* DOUGL. VAR. *LATIFOLIA* ENGELM.) PAR ROGER BEAUDOIN

Mots-clés: Tests de descendances, tests de provenances, sélection d'arbres, croisements dirigés, inoculation.

Le Service de l'amélioration des arbres a poursuivi l'établissement de tests de descendances sur *P. banksiana* et la réalisation de croisements dirigés sur *P. banksiana* et *P. contorta* var. *latifolia*.

En 1990, 4 tests de descendances sur *P. banksiana* ont été établis en rapport avec l'établissement de vergers à graines de semis, ce qui porte à 17 le nombre total de tests de descendances.

En 1990, 522 greffes ont été réalisées à partir de greffons prélevés sur les plants sains de 27 provenances de pin gris inoculés artificiellement en champs pour tester la sensibilité de 41 provenances à la maladie du chancre scléroderrien. Dans un autre test, l'inoculation en masse sous tunnel de semis en contenant âgés de 1 an, à partir de branches portant des fructifications du champignon, a causé l'infection sévère de presque tous les semis.

Une étude de la variation de la densité basale du bois sur 960 arbres âgés de 11 ans, provenant de 80 descendances sélectionnées pour la hauteur dans un verger à graines, a été réalisée au moment de l'éclaircie sélective en 1990 par 2 étudiants en génie forestier (mémoire de fin d'étude) en collaboration avec le ministère des Forêts. Les résultats seront utilisés surtout pour la préparation du plan de croisements dirigés entre les meilleures descendances de la provenance Briand.

En 1989 et 1990, 30 croisements dirigés ont été effectués sur *P. banksiana* entre les clones d'arbres-plus d'une provenance recommandée (Briand). Des croisements interprovenances, 35 au total, ont aussi été réalisés durant cette période entre les meilleurs clones de la provenance Briand et 5 provenances classées parmi les meilleures dans le test de 64 provenances du canton Fontbrune situé près de celui de Briand. Plusieurs croisements dirigés ont été effectués entre les meilleures provenances de *P. contorta* var. *latifolia*.

SÉLECTION D'ARBRES ET ÉTABLISSEMENT DE VERGERS À GRAINES,
PAR Y. LAMONTAGNE ET A. RAINVILLE

Mots-clés : Vergers à graines, sélection d'arbres, résineux, greffes, densité du bois.

Cette activité a pour objectif l'établissement et l'aménagement d'un réseau de vergers à graines pour les résineux qui fournira éventuellement toutes les semences améliorées génétiquement nécessaires pour le programme de reboisement du ministère des Forêts.

À cette fin, les travaux de sélection d'arbres se sont poursuivis depuis 1989 et 72 nouveaux candidats ont été identifiés, ce qui porte à plus de 20 000 le nombre total d'arbres-plus. Au centre de greffage de Duchesnay, 4 294 greffes ont été réalisées.

Des travaux de préparation de terrain ont été effectués sur 73 ha tandis que des travaux d'entretien ont eu lieu sur 920 ha de vergers déjà établis. De plus, la plantation de 11 nouveaux vergers aux printemps de 1989 et de 1990 (comprenant 48 ha du type clonal et 70 ha du type de semis) porte à 65 le nombre total de vergers établis et à 993 ha, la superficie plantée.

Six vergers à graines ont produit un total de 87,2 hectolitres de cônes jusqu'à présent. Des récoltes expérimentales ont été effectuées dans deux vergers pour vérifier la qualité des graines et établir des différences clonales et familiales. Une méthode de détection et d'identification des insectes et maladies des cônes a été mise à l'essai en 1990 dans les vergers; elle a pour but de déterminer la nature et l'ampleur des principaux pathogènes, d'établir des seuils d'intervention et d'agir comme méthode préventive. Finalement, un essai d'étêtage a été réalisé sur quelques blocs d'un verger à graines de pins gris pour mesurer des différences possibles au niveau de la quantité et la qualité des graines.

AMÉLIORATION GÉNÉTIQUE DES FEUILLUS À BOIS NOBLE,
PAR J. MACKAY

Mots clés : Amélioration génétique, croisements dirigés, feuillus nobles, sélection d'arbres, greffage

L'implantation de programmes d'amélioration génétique du chêne rouge (*Quercus rubra* L.) et du bouleau jaune (*Betula Alleghaniensis* Brit.) progresse rapidement. Des sélections d'arbres-plus de frêne blanc (*Fraxinus americana* L.) débuteront en 1991.

Divers essais de greffage ont permis d'identifier les meilleures méthodes à utiliser pour plusieurs espèces feuillues à bois dur. Certaines méthodes devraient permettre la rejuvénilisation nécessaire pour le bouturage d'arbres matures chez quelques espèces. Enfin, une mission a été réalisée en Indiana et Ohio pour obtenir des informations scientifiques et techniques reliées à la génétique et à l'amélioration du chêne rouge, du noyer noir et de l'érable à sucre.

Une centaine d'arbres-plus de chêne rouge ont été sélectionnés en forêt et greffés en vue de l'établissement de parcs à croisements. Chaque parc à croisements comportera une lignée (subline) de la population d'amélioration. Au total il y en aura 6 et chacune sera constituée de 30 clones. Les semences obtenues par pollinisation libre dans ces parcs seront évaluées par des tests de descendances pour ensuite constituer la deuxième génération dans un processus de sélection récurrente. Des récoltes de glands de chêne rouge ont été réalisées sur 180 arbres du Québec, de l'Ontario et du nord-est des États-Unis à l'automne 1990. Avec ces semences, des tests de provenances-descendances seront établis en 1993 sur divers sites dans le sud du Québec. Ces tests permettront de préciser les limites de déplacement de semences et d'ajuster le contour de la (des) zone(s) d'amélioration. Ils permettront aussi d'identifier des familles et des géniteurs supérieurs pour la deuxième génération d'amélioration et comme source de semences pour le reboisement.

Plus de 120 arbres-plus de bouleau jaune ont été sélectionnés. Plusieurs de ces arbres ont fait l'objet de croisements dirigés intraspécifiques et interspécifiques avec *Betula papyrifera*, *B. verrucosa* et *B. pubescens*. Le greffage en bouteille nous a permis de réaliser les croisements dirigés sous abri la même année que la sélection en forêt. Des 160 lots de semences hybrides obtenus, 63 ont germé et ce à des taux généralement assez faible. D'autres croisements interspécifiques sont présentement en cours.

SÉLECTION DE CLONES ET AMÉLIORATION DU PEUPLIER

PAR G. VALLÉE ET M.-J. MOTTET

Mots-clés : *Populus*, test de provenances et de descendances, test clonal, sélection de clones, croisements. *Septoria musiva, Hypoxylon mammatum*.

En 1989 et 1990 quelque 9 dispositifs de tests clonaux ont été établis avec une nouvelle série de clones résistants à *Septova musiva*, Pk. Ces dispositifs sont situés surtout dans les régions de l'Abitibi-Témiscamingue et du Saguenay-Lac-Saint-Jean où la populiculture est en développement.

Durant ces deux dernières année 1 107 plants ont été sélectionnés pour leur résistance aux maladies foliaires et aux chancres (*Septoria musiva Pk, Hypoxylon mammatum* (Wahl) J.H. Mullar). Ces plants sont en cours de clonage afin de les évaluer en test précoce.

En résumé, à ce jour, un total de 2 937 clones ont été sous observation au S.A.A., dont 545 ont été sélectionnés dans les peuplements naturels au Québec et 1 633 dans des plantations comparatives; 759 autres clones ont été introduits surtout d'Europe et d'Ontario. De plus 57 dispositifs de tests clonaux, 13 plantations de collections de clones, 28 dispositifs de tests de provenances et descendances ont été mis en place. Quelque 2 784 croisements ont été faits dont 355 ont donné des semis. Ajoutons l'obtention de pays étrangers de 257 lots de semences et de récoltes au Québec de 433 lots de semences représentant 27 espèces ou hybrides.

Depuis 1986, l'ensemble des clones du S.A.A. (environ 1 300) à la pépinière de Lotbinière, ont été inoculés et les clones peu sensibles ont été testés avec quatre isolats de *S. musiva* dans les quartiers de pieds-mères. Les quelque 250 clones considérés peu sensibles ont été sélectionnés et les clones trop sensibles et non recommandés par le S.A.A. son maintenant exclus des nouveaux quartiers de pieds-mères et tests clonaux pour le sud de la province.

Des 2 300 semis inoculés depuis 1987, 569 semis ont été retenus pour leur faible sensibilité, ont été clonés, et ont été inclus ou 1990 dans un test précoce à Lotbinière. En 1990, des 650 semis inoculés avec deux isolats, 300 ont été évalués peu sensibles à *S. musiva*. Un dispositif de 20 clones appartenant à différents hybrides et représentant une gamme de sensibilité a été installé. Ce dispositif a pour but d'évaluer la virulence de plusieurs isolats au champ.

Depuis 1989, une méthode d'inoculation est également à l'essai avec le champignon *H. mammatum*. Cet agent pathogène cause des chancres principalement sur les peupliers de la section Leuce. Quelque 1 300 semis de peuplier de cette section ont été inoculés avec un isolat aux pépinières de Duchesnay et Lotbinière. Différents bioessais en laboratoire qui pourraient permettre l'évaluation rapide de la sensibilité des semis ou clones, sont présentement à l'étude.

AMÉLIORATION DES MÉLÈZES (LARIX SP.) ET DE L'ÉPINETTE DE NORVÈGE (*PICEA ABIES* KARST.), PAR A. STIPANICIC

Mots-clés: Tests de descendances, tests de provenances, croisements dirigés, vergers à graines

Chez les mélèzes, l'accent a été mis sur les croisements dirigés interspécifiques en vue de produire des hybrides à partir des arbres de mélèze d'Europe et du Japon. En 1989, nous avons effectué 185 croisements dirigés qui nous ont donné 113 lots de semences : 78 lots de mélèze d'Europe x mélèze du Japon, 33 de mélèze du Japon x mélèze d'Europe et 2 de mélèze d'Europe x *L. gmelini*. En 1990 la floraison sur les arbres sélectionnés était plus faible et nous avons obtenu seulement 16 lots de semences issues de 16 croisements dirigés de mélèze d'Europe avec le mélèze du Japon. Les 113 lots des croisements de 1989 ont été semés au Centre de bouturage de Saint-Modeste. Le nombre de semences par lot varie considérablement dû non seule ment au nombre de cônes qui se sont développés après la pollinisation mais aussi au nombre très variable de graines viables par cône. Les semis obtenus seront multipliés par bouturage et serviront en partie pour un test de descendances. Le reste sera utilisé pour le reboisement.

Le traitement d'induction florale (1,7 mg ou 3,0 mg d'ANA selon la taille de la greffe) a été appliqué sur 46 ramets de 18 clones de mélèze du Japon et 60 ramets de 20 clones de mélèze d'Europe à l'été 1990.

Il faut aussi noter l'établissement, en 1989, d'un test composé de 40 descendances obtenues soit par croisement dirigé, soit par pollinisation libre dans notre parc à clones, et l'agrandissement du parc à clones de mélèze dans l'arboretum de Villeroy qui compte maintenant 290 clones de *L. decidua*, 99 clones de *L. leptolepis* et 27 clones de *L. laricina*.

Concernant l'épinette de Norvège, nous avons poursuivi notre plan de croisements dirigés entre les arbres sélectionnés dans les provenances recommandées pour les zones d'amélioration B et C. Ainsi, 128 croisements ont été effectués en 1990 et les 100 lots de graines obtenus ont été semés en novembre dernier. Comme dans le cas du mélèze, nous avons constaté d'importantes variations dans le nombre de graines obtenues par cône et dans leur taux de germination. En vue d'améliorer les résultats de nos croisements dirigés et d'augmenter la production des graines, nous avons effectué l'induction florale sur 30 ramets (30 clones sélectionnés) par l'injection de 0,2 mg d'$AG_{4/7}$.

En collaboration avec l'équipe de généticiens de Forêts Canada (Québec), nous avons installé deux tests de provenances-descendances dans les pépinières de Saint-Modeste et de Sainte-Luce. Ces tests, qui regroupent 275 lots de graines seront transférés sur le terrain en 1992. Ils font partie de la première série de 9 tests, dont le but est de délimiter avec plus de précision les zones d'amélioration de l'épinette de Norvège au Québec, d'évaluer les qualités de plusieurs descendances étrangères (en particulier, polonaises), et d'obtenir du nouveau matériel nécessaire à la poursuite du programme d'amélioration de cette espèce.

Dans cinq de nos plantations expérimentales d'épinette de Norvège, nous avons effectué une éclaircie sélective. Le but de ce travail était de transformer les anciens tests en sources de graines améliorées disponibles immédiatement pour subvenir aux besoins en reboisement en attendant que les vergers à graines n'entrent en production.

AMÉLIORATION DE L'ÉPINETTE NOIRE (*PICEA MARIANA*), PAR M. VILLENEUVE

L'épinette noire représente environ 52 % du programme de reboisement au Québec, d'après les ensemencements de 1990. Toutes les régions de la province prévoient l'utiliser dans les reboisements.

En 1990, seulement deux tests ont été installés. Il s'agit de tests précoces en pépinière, et les plants sont des boutures racinées produites au Centre de bouturage de Saint-Modeste. Cette année, un test précoce, six tests à long terme de boutures racinées et trois tests de descendances de 1^{e} génération s'ajouteront à la liste, pour un total de 79 dispositifs expérimentaux. Les trois derniers tests de descendances accompagnant les vergers de 1re génération seront établis en 1992.

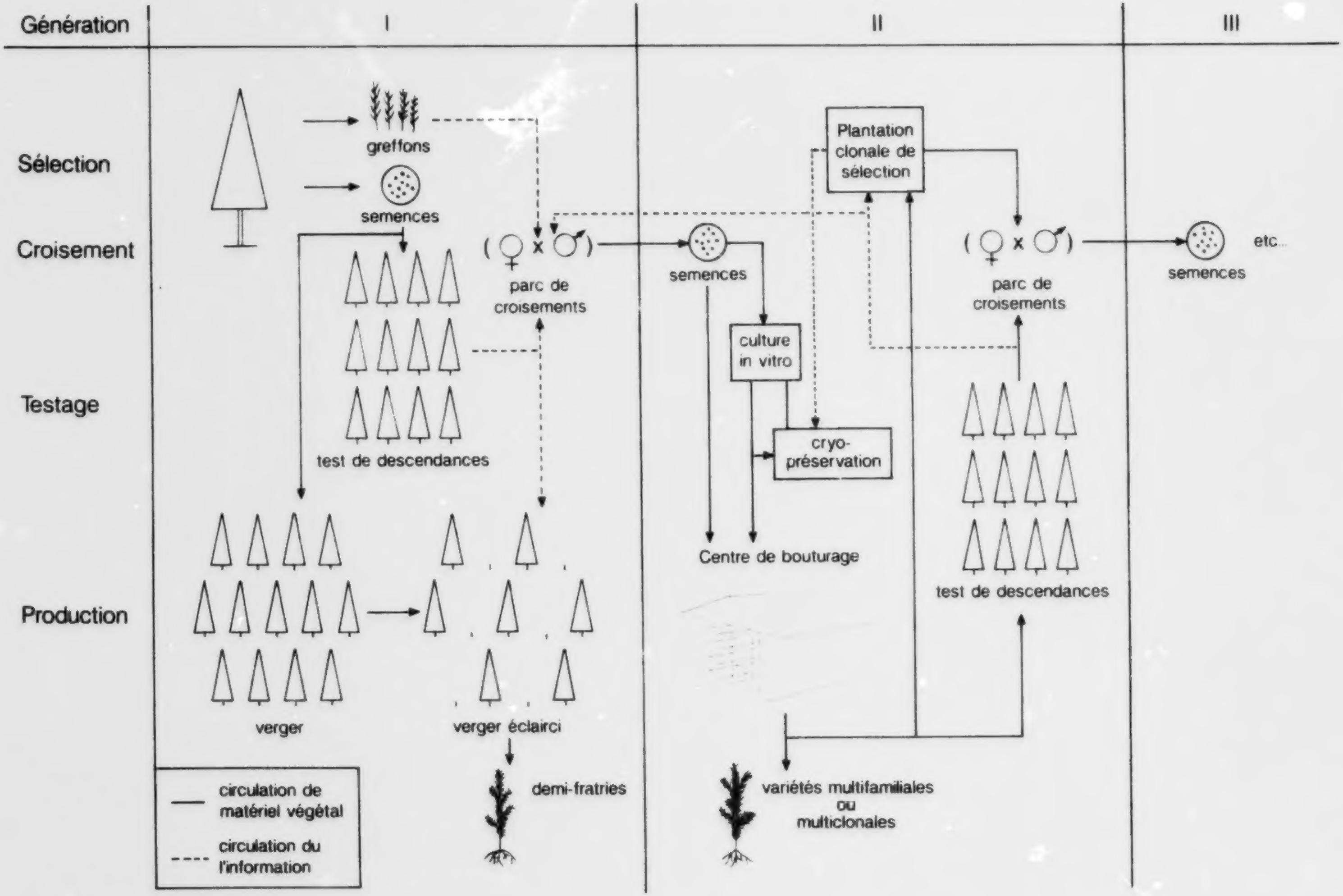
En fonction de l'information disponible dans les plus vieux tests, nous réalisons des croisements dirigés pour deux zones d'amélioration (sud du Québec et Appalaches). Les semences qui originent des croisements dirigés dans les parcs de croisements sont utilisées pour la production de semis qui serviront de pieds-mères. La multiplication végétative de ces semis de qualité génétique accrue, mais disponibles en quantité limitée, se fait par bouturage au Centre de bouturage de Saint-Modeste. La majorité des butures racinées est utilisée pour le reboisement (variétés multifamiliales). L'autre partie de ces boutures sert à l'installation de tests de descendances. Les résultats des tests permettront de choisir quels sont les croisements qui doivent être répétés année après année pour approvisionner le Centre de Saint-Modeste.

Une voie intéressante pour la génération II utiliserait la culture d'embryons somatiques combinée à la cryo-préservation. Il deviendrait possible de faire une sélection des meilleurs clones des meilleurs croisements et, grâce à la cryo-préservation des cals embryogènes, de pouvoir remettre en production les clones sélectionnés tout en conservant leur juvénilité.

Au Centre de Saint-Modeste, un test visant à évaluer l'aptitude en bouturage est en marche. Quarante familles ont été choisies pour déterminer une façon d'identifier le plus tôt possible les familles qui se multiplient bien par bouturage. Les résultats préliminaires nous ont conduit à modifier le dispositif expérimental pour mieux tenir compte des variations micro-climatiques à l'intérieur de la bouturathèque. L'évaluation de l'aptitude au bouturage se poursuit.

Les zones d'amélioration actuelles ont été délimitées selon les régions écologiques, tout en évitant un trop grand morcellement du territoire. Pour vérifier l'homogénéité de ces zones d'amélioration, une méthode d'analyse a été mise au point par des étudiants en statistique (Coté et coll., 1991). Dans le cadre d'un projet de fin d'études, ils ont utilisé une partie des données de la série de tests de provenances de 1984. Un seul des six sites étudiés se distinguait des autres, cinq ans après plantation. Ceci originerait vraisemblablement de la meilleure qualité du site (meilleure croissance) et du dispositf (efficacité statistique des blocs aléatoires).

Rôle du Centre de bouturage dans le processus d'amélioration génétique


Génération
I
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Sélection
Croisement
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culture in vitro
cryo-préservation
Centre de bouturage
Plantation clonale de sélection
variétés multifamiliales ou multiclonales
(♀ x ♂)
parc de croisements
test de descendances
semences
etc...
circulation de matériel végétal
circulation du l'information

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GÉNÉTIQUE FORESTIÈRE À FORÊTS CANADA - RÉGION DU QUÉBEC

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Mots clefs: *Pinus strobus, Picea glauca, Picea abies, Pinus griffithii, Pinus koraiensis, Pinus peuce, Abies balsamea,* induction florale, qualité du bois, tests génécologiques, structure génétique, analyses isoenzymatiques, culture in vitro.

Les recherches en génétique forestière à Forêts Canada - région du Québec se sont poursuivies au cours de la période 1989-1991 par la mise en place d'une première série de tests génécologiques d'épicea commun et d'un test génétique de pin blanc en plantation mixte. De plus, une étude de la variabilité génétique chez l'épinette blanche a été réalisée de même qu'une étude de la variation de la densité du bois chez l'épicea commun. Deux projets de recherche basés sur les analyses isoenzymatiques ont également été initiés. L'un étudie la structure génétique des populations naturelles de pin blanc, l'autre compare les niveaux de variabilité génétique dans le matériel sélectionné à celui existant dans les populations naturelles d'épinette blanche. Les traitements d'induction florale par pulvérisation ou injection ont permis qu'accélérer la réalisation de notre programme de croisements. En culture in vitro du pin blanc, des cals embryogènes ont été obtenus à partir d'embryons zygotiques immatures.

RÉALISATIONS EN GÉNÉTIQUE CONVENTIONNELLE

Mise en place et suivi des dispositifs expérimentaux

Épicea commun (*Picea abies* L. Karst)

La section méridionale du Québec constituant le territoire propice à la plantation de l'épicea commun a été subdivisée en trois zones d'amélioration. Nous avons entrepris d'implanter dans chacune de ces zones trois tests génécologiques distribués de façon à bien représenter les conditions pédoclimatiques de la zone. Ces tests ont pour objectif principal de confirmer les frontières des zones proposées et, s'il y a lieu, de les subdiviser en plus petites unités. Ces tests comprennent plus de 300 demi-fratries et provenances dont 150 demi-fratries d'origine polonaise provenant de régions à fort potentiel pour le Québec.

À ce jour, les semis produits en serre pour la zone des Appalaches sont en pépinière pour une deuxième année consécutive et seront transférés au printemps 1992 dans les trois sites choisis . Des données phénologiques et phénotypiques seront recueillies à l'été 1991 en pépinière afin de caractériser ces populations et familles et d'évaluer leurs performances juvéniles.

Les tests génécologiques de la zone des Laurentides ont été initiés sous serre en février 1991 et seront repiqués en pépinière au printemps 1992. La production et l'établissement de ces tests sont entrepris en collaboration étroite avec le Service d'amélioration des arbres forestiers du ministère des Forêts du Québec.

Pin blanc (*Pinus strobus* L.)

Nous avons effectués le suivi et l'entretien sylvicole des cinq tests génécologiques de pins blancs mis en place au milieu des années 80. Nous effectuerons à l'été 1991 un relevé des données phénotypiques, 5 ans après la plantation, dans deux de ces tests. Au cours de la dernière période, nous avons également installé un test génétique comprenant 225 demi-fratries de pin blanc en plantation mixte avec *Alnus incana* à Saint-Joseph-de-Lévis, Québec. De plus, le matériel de ce test a été implanté en dispositif de démonstration avec et sans *A. incana* dans le secteur d'amélioration de Valcartier.

Caractéristiques économiques

Épinette blanche (*Picea glauca* (Moench) Voss.)

Au début des années 80 un test génétique régional d'épinette blanche, comprenant au-delà de 350 demi-fratries et provenances a été mis sur pied. Des données morphologiques et phénologiques ont été recueillies en serre et en pépinière. Par la suite, 11 tests génécologiques ont été établis dans la section méridionale du Québec. Un premier mesurage a été réalisé 5 ans après la plantation. Une étude de la variabilité génétique au niveau familial d'une vingtaine de caractères a été réalisée. De plus, des corrélations spatiales et temporelles ont été calculées. Un article scientifique rapportant les résultats de ces travaux a été soumis pour publication. Un second article portant sur la variation géographique de l'épinette blanche et sur le déplacement des semences est en préparation.

De plus, au cours de la période 1989-1991, les études portant sur la variabilité phénotypique et génétique de la densité du bois et de la croissance radiale de l'épinette blanche ont été complétées. Deux publications (Corriveau et collab. 1990; Corriveau et collab. 1991) ont été produites. La première fait rapport de la variation densimétrique du bois de 28 populations de la région forestière des Grands Lacs et du Saint-Laurent, 20 ans après plantation. On y montre l'existence d'un même patron de variation radiale. Les différences entre les arbres d'une même population expliquent au delà de 85 % de la variation. Une sélection massale axée sur la densité relative du bois effectuée dans les populations à croissance rapide a été recommandée.

La seconde publication montre qu'on peut espérer des gains génétiques de l'ordre de 16 %, 3 % et 12 % chez la largeur de cernes, le pourcentage d'humidité et la densité du bois de l'épinette blanche respectivement, suite à une sélection combinée d'une famille sur 10 et d'un arbre sur 100 à l'intérieur des familles retenues. Ces résultats sont attendus environ 20 ans après la plantation.

Épicea commun

Une étude de la variation de la densité du bois dans la tige et de la longueur des fibres chez l'épicea commun a été entreprise. Le matériel utilisé provient d'un essai comprenant 22 provenances originant d'Europe centrale. Il a été récolté et analysé par M. Donald Blouin qui terminera en 1991 une maîtrise en sciences du bois à l'Université Laval.

ASPECTS BIOTECHNOLOGIQUES ET BIOCHIMIQUES

Structure génétique et conservation de la diversité génétique

Pin blanc

Une étude de la structure génétique des populations naturelles de pins blancs du Québec a été entreprise. Dix populations ont été échantillonnées en 1989 et 1990. Quatre régions sont représentées. Des semences ont été récoltées sur 30 arbres dans chaque population. Douze systèmes enzymatiques s'exprimant chez les mégagamétophytes ont été étudiés en utilisant la méthode des gels d'acétate de cellulose. Les fréquences alléliques ont été obtenues et les génotypes ont été inférés. Les analyses se poursuivent et les résultats seront publiés au cours des deux prochaines années.

De plus, 10 cônes par arbre ont été choisis au hasard parmi ceux récoltés et ont fait l'objet d'une analyse de la variation morphométrique. Ces dernières démontrent une différentiation des populations et des régions d'origine. Des analyses canoniques permettront de comparer les patrons de variation observés chez les cônes et chez les formes moléculaires d'enzymes. Une publication est en préparation et une affiche a été réalisée. Finalement, deux exposés oraux ont été présentés.

Épinette blanche

Une étude consacrée à la variabilité génétique présente au niveau des formes moléculaires d'enzymes chez l'épinette blanche a été réalisée par la Dre Mireille Desponts, stagiaire post-doctorale. Les populations examinées sont représentées dans le programme d'amélioration génétique chez cette essence au Québec. Ainsi, on a vérifié si le processus de sélection s'était traduit par une baisse de la variabilité génétique. Cette dernière, présente chez deux populations naturelles, a été comparée à celle de trois provenances et à celle d'un groupe d'individus impliqués dans le programme d'amélioration. Les résultats indiquent que le niveau de variabilité génétique généré par les gènes qui codent les allozymes est maintenu après la sélection.

Culture in vitro du pin blanc

Les premiers essais de culture in vitro du pin blanc ont été réalisés à l'été 1990. Des cônes immatures issus de la pollinisation libre de strobiles femelles produits dans le parc d'hybridation de l'espèce à Cap Tourmente ont été récoltés hebdomadairement du 23 juillet au 13 août et les gamétophytes ont été placés sur un milieu d'induction. Des tissus embryogènes ont été obtenus à une fréquence variant de 0 à 15 % selon les génotypes, les milieux et les dates de récolte. Les lignées embryogènes sont présentement évaluées pour leur aptitude à régénérer des embryons somatiques. La mise au point du milieu de culture et la détermination des conditions de culture requises pour l'embryogenèse somatique du pin blanc à partir d'embryons zygotiques matures font l'objet d'expérimentation.

Induction florale et pollinisation dirigée

Au cours des deux dernières années, nous avons poursuivi les traitements d'induction florale afin de faciliter la réalisation de notre programme de croisements dirigés. Pour l'épinette blanche, le traitement de pulvérisation de AG 4/7 continue de donner d'excellents résultats. Ainsi en 1990, par exemple, 84 % des greffes induites ont produit en moyenne 127 strobiles femelles. La productivité variait de 3 à 450 strobiles dépendamment du génotype. Ces traitements ont permis de réaliser plus de 230 croisements dirigés. Chez l'épicea commun, 45 % des greffes traitées ont produit en 1990 des strobiles femelles avec une moyenne de six cônes par greffe. Les croisements dirigés réalisés sur ces greffes ont été peu productifs.

Durant l'été 1990, plusieurs essais d'induction florale par pulvérisation et/ou injection de AG 4/7 ont été entrepris chez le pin blanc, l'épinette blanche et l'épicea commun. Les données seront recueillies et analysées à l'été 1991. À ce jour, l'induction florale par l'injection d'un mélange de AG 4/7 et de ANA semble donner les meilleurs résultats pour 75 % des 20 clones traités en champ tant au niveau des strobiles mâles que femelles.

En préparation de travaux d'induction florale et de croisements dirigés interspécifiques, 10 génotypes de *Pinus griffithii*, 9 de *P. koraiensis* et 14 de *P. peuce* ont été multipliés par greffage et placés dans des conditions de croissance accélérée.

AUTRES ACTIVITÉS

Un test génétique comprenant 23 familles de sapins baumiers (*Abies balsamea* (L.) Mill.) établi en 1972 a fait l'objet d'analyse. Les paramètres génétiques ont été évalués à trois âges, soient 9 ans, 14 ans et 21 ans. Des gains génétiques supérieurs à 20 % en croissance et qualité de tige sont escomptés des descendants d'un âge équivalent à celui des parents au dernier mesurage. Un rapport d'information présentant les résultats a été préparé.

Lors du dernier congrès mondial de l'IUFRO, nous avons présenté les résultats de nos programmes d'amélioration dans le cadre d'une excursion post-congrès comprenant un arrêt à la station forestière expérimentale de Valcartier. Les études effectuées sur l'épicea commun, l'épinette noire, l'épinette rouge et le pin blanc y ont été décrites.

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CANADIAN PACIFIC FOREST PRODUCTS LIMITED HARRINGTON FORESTRY CENTRE AND ST. MAURICE WOODLANDS, QUEBEC

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BACKGROUND

In 1980, a tree improvement programme was initiated by Canadian Pacific Forest Products Ltd. in Quebec, following two years' involvement in the New Brunswick Tree Improvement Council through its subsidiary, NBIP Forest Products Ltd. The programme's objective in Quebec is primarily to produce genetically superior seedlings for the Company's reforestation programme on its upper St. Maurice freehold in central Quebec, as well as on public lands managed under its CAAF agreement.

Selection of plus trees was done from 1980 to 1984 in the Gouin (B-3) boreal region. The principal seed orchard complex is located at the Company's Harrington Forestry Centre in southwestern Quebec, and a small orchard is established at Batiscan, near Three-Rivers, Quebec.

Canadian Pacific Forest Products' Quebec tree improvement programme concentrates on black spruce (*Picea mariana* [Mill.] B.S.P.) and jack pine (*Pinus banksiana* Lamb.), with some work being done on Japanese larch (*Larix leptolepis* [Sieb. and Zucc.] Endl.), European larch (*L. decidua* Mill.) and Norway spruce (*P. abies* [L.] Karst). At Harrington, a clonal white spruce (*P. glauca* [Moench] Voss) seed orchard established using clonal material from New Brunswick will produce seeds for NBIP Forest Products' tree planting programme.

In 1990 the Company signed a tree improvement agreement with the Quebec Ministry of Forests (MFO) for an initial ten year duration. This agreement, the first of its kind in the tree improvement sphere in Quebec, demonstrates the close collaboration between the provincial forestry authorities and the Company. Subject to budgetary constraints, the MFO agrees to purchase cones coming from Company orchards and to pay for specifically agreed upon orchard and family tests management costs, and to provide the Company with technical guidance related to the programme (recommendations concerning orchard roguing and management practices, etc.) The Company, for its part, receives no compensation for the over $1 million invested in setting up its tree improvement programme since 1980. It retains ownership of the established material and maintains many of the surveillance responsibilities.

JACK PINE FAMILY TESTS

Originally, it was decided to measure the jack pine family tests after 7 and 10 growing seasons, with another possible measurement after 12 seasons. However, more recently the 10 year measurement has been abandoned in favour of the 12 year measurement.

In 1990 measurements continued for the 7 year growth results in test 1 (26 families measured) and half the families (246) established in test 2 were evaluated.

Control of the pitch nodule maker (Petrova albicapitana) continued by manually destroying the nodules in both tests, which were quite numerous. Some dead trees in both tests were removed, the cause most likely due to Armillaria.

In 1991 the 7 year measurement will be completed for both tests by evaluating 255 families in test 1 and 249 families in test 2. Insect and disease control measures will continue as needed. Following the CPFP/MFO tree improvement agreement, the family test data will be analyzed during 1991 for a planned first roguing of the seed orchard in 1992.

BLACK SPRUCE FAMILY TESTS

The first measurement will be made after 10 growing seasons, and should begin in the fall of 1991. It was decided to delay measurements to year 10 due to the slow development of these trees.

JAPANESE LARCH

In the fall of 1990 the Batiscan seedling orchard site was thinned in order to provide growing space for the trees which had attained the 8 m range. Thinning intensity was 23%, based on the 1989 measurement results. The cut was mainly a cleaning operation since most of the trees removed were deformed, wounded or slow growing. Individuals were cut as permitted by the thinning design. The last thinning will be done in a few years, based on results of the 1989 or more recent measurements.

HARRINGTON SEED ORCHARD

Table 1 provides a breakdown of the orchard complex, which contains four species. In June 1990 a high larval population of the June bug (Phyllophaga anxia) killed a few hundred white spruce ramets. An application of Lorsban hopefully eliminated the problem. A second application will be done in the spring of 1991.

The first cone harvest was carried out in the jack pine seedling seed orchard in the fall of 1989. Ten employees worked for 10 days and were able to harvest 17,5 hl of cones from trees planted in 1984, which yielded 24,2 kg of processed seeds, ready for sowing.

In 1990 the first complete harvest was done in the same orchard. A total of 107,8 hl of cones were harvested, with a processed seed yield of 137,7 kg. This represents approximately double the seed yield from general collections of this species in Quebec according to MFO personnel.

The first roguing of the jack pine orchard is scheduled for 1992, when about 50% of the trees will be removed.

Table 1. Harrington Seed Orchard Information Summary

Species	Type[1]	Area[2] (ha)	Number of Families (F) / Clones (C)	Planted	Clone Bank	Clone Bank Area (ha)
Black Spruce	S	16,6	440 F	1985/86	yes	2,3
Jack Pine	S	12,0	480 F	1984/85	yes	2,5
White Spruce	C	6,0	65 C	1987/88	no	-
Norway Spruce	C	1,6	120 C	1984 & 86	yes	0,2

[1] S: Seedling seed orchard; C: Clonal seed orchard

[2] Area in production

PROGRESS AND INITIATIVES IN ONTARIO'S TREE IMPROVEMENT PROGRAM

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Keywords: tree improvement, breeding, seed orchards, genetic testing, vegetative propagation

Tree improvement in Ontario is implemented at a regional level, with each region having a unique program of activities and species to meet local needs and objectives. General components of these programs are varied and currently include controlled seed collection areas, first generation seed orchards and associated field testing, short-term testing, accelerated breeding and breeding halls, vegetative propagation, clonal forestry, and gen-ecology studies.

The species of primary emphasis in tree improvement are black spruce (*Picea mariana* (Mill.) B.S.P), jack pine (*Pinus banksiana* Lamb.), and white pine (*Pinus strobus* L.). Other species include white spruce (*Picea glauca* (Moench) Voss), Norway spruce (*Picea abies* (L.) Karst), red spruce (*Picea rubens* Sarg.), tamarack (*Larix laricinia* (Du Roi) K. Koch), Japanese larch (*L. leptolepis* (Sieb. & Zucc.) Gord.), European larch (*L. decidua* (Mill.)), black walnut (*Juglans nigra* L.), white ash (*Fraxinus americana* L.), red oak (*Quercus rubra* L.), and poplars (*Populus* L).

TREE IMPROVEMENT AND TECHNOLOGY TRANSFER UNIT

A current, major initiative in Ontario is the development of a new tree improvement co-operative structure, one encompassing the entire province. The aim of the co-operative is to foster local ownership, participation, and partnerships, while enhancing the delivery of tree improvement programs. Six local operational co-operative zones are planned. Within each zone, ministry and industry participants will determine program goals, priorities, and activities for the zone. All zones will receive scientific and technical support through a provincial technical committee.

A second initiative entails collating weather data from across the province to identify consistent patterns and trends in major climatic variables that might affect genetic variation of tree species. Simultaneously, studies are being initiated to examine the nature and magnitude of genetic variation among natural populations of some major species. Ultimately, this information will be used to modify boundaries of existing breeding and seed zones, to better correspond with areas of significant genetic differentiation.

In 1990, development of a cone crop monitoring system began in several orchards across the province. The system provides a means of tracking cone development and inventories in production orchards. The aim of this work is to develop a tool to help orchard managers predict cone and seed yields, and identify times and causes of excessive seed loss. Development work on the system continues in 1991.

Many seed orchards in the province are ready (or nearly so) for their first roguing. Consequently, many supporting field tests will be assessed in the coming year to provide data that will be analyzed to determine appropriate roguing regimes. To facilitate data collection with data loggers, a general test assessment program system has been developed which is suitable for use in most genetic tests of the province.

At the Island Lake Tree Improvement Area, Dr. F. Di-Giovanni is conducting research on physical factors affecting pollen movement and contamination in seed orchards. Part of this work will yield a general bio-mathematical model to predict levels of pollen contamination and identify major contributing factors. The model should help orchard managers in making management decisions that affect pollen efficiency.

A summary of the improvement activities by region and species follows.

NORTHWESTERN REGION

Black Spruce

A large measurement, analysis and roguing program is scheduled for orchards and family tests established ten years ago. Two family tests and one seed orchard were measured in 1990/91 in Red Lake District. Roguing will be conducted during the summer of 1991. Another ten seed orchards with associated family tests (20 tests) will be measured this fall in Dryden, Fort Frances, Ignace, Kenora, and Sioux Lookout Districts. Seed orchards are scheduled to be rogued by 1992.

A trial to study fertilization for cone induction was established in both Ignace and Kenora Districts during 1990. The trials will assess the effect of different times of application and different rates of application of ammonium nitrate fertilizer on cone production. First year measurements will be taken this spring with the trials scheduled to last several years.

Jack Pine

In the spring of 1990, Kenora District established one seed orchard and three family tests. This spring (1991), Ignace, Red Lake, and Sioux Lookout Districts are establishing a total of three seed orchards and nine family tests. This will complete the establishment phase of this program with six seed orchards and 18 family tests. A climate-based model developed by Environment Canada is used in making irrigation decisions in all seed orchards.

A crown pruning study was established in Sioux Lookout District in the fall of 1990 and another is scheduled to be established in Kenora District this fall (1991). The trials will evaluate the effect of different levels of pruning over several years on height growth, crown form, and cone production.

White Spruce

Six clonal orchards have been established and are being maintained.

NORTH CENTRAL REGION

The North Central region implements the tree improvement program co-operatively with the Ontario Tree Improvement Council.

Breeding Orchard

The breeding orchard, established in Thunder Bay in 1988, continues to be filled with clonal stock from the old black and white spruce programs. In 1991, the first material of the new program was established in this orchard. Jack pine grafted stock from the Nipigon West breeding zone was planted. The breeding orchard will also serve as the clonal archive for the region.

Black Spruce

Two 16-ha seed orchards (Abitibi 1; Ministry 1) and four family tests (Abitibi 2; CPFP 1; Ministry 1) were established in the Nipigon West breeding zone. Mortality in the seed orchards necessitates additional planting in 1992. Old-program clones that are missing from the breeding orchard were regrafted 1989 and 1990. These grafts will be planted in the breeding orchard when of sufficient size.

The program for the 4400 breeding zone is presently being established. Four hundred plus tree selections have been made which include six trees from the old program (Pearson Orchard) and four standards from seed collection areas (one per set). Three family tests (CPFP 2; Ministry 1) are being established and the Ministry has established a 16-ha seed orchard.

In the Nipigon East breeding zone, pollination work using a polymix is continuing. To date, obtaining sufficient seed for a proposed orchard and family tests remains a problem. However, open-pollinated seed collected from the Longlac and Matawin Orchards may be used for a farm field test of this material.

Jack Pine

The program in the Nipigon West breeding zone continues with a 14-ha seed orchard (CPFP) and four family tests (CPFP 2; Abitibi 1; Ministry 1). Damage from white pine weevil and pine shoot borer are problems in the family tests. Deer remain a problem in the seed orchard. Measurements on the family tests are scheduled for autumn of 1991.

In the 4400 breeding zone, 430 plus trees have been selected. Seedlings are presently being grown for establishing a 10-ha seed orchard and three family tests in 1992. Work in the Nipigon East breeding zone has begun, with the selection of 216 plus trees to date. This will be the base of the program; it will be supplemented when remaining partner members come into the program.

White Spruce

The O'Connor seed orchard has been re-designed to improve pollen distribution. A polymix mating design will be used to produce seed for testing clones in the future.

NORTHERN REGION

Since the 1989 completion of the establishment phase of first generation improvement work, more emphasis has been put on seed orchard management and making progress toward second generation improvement.

Black Spruce

A genecology study was initiated in 1990. The objective is to examine the genetic variation of the species in relation to environmental variation. The information will be used to realign seed zone and breeding zone boundaries if necessary and to ensure that the allocation of seed and deployment of seedlings and stecklings is to sites where they are well adapted. Cone collections were made to represent the land base of the region; the seeds have been sown and will be planted at two sites for assessment over the next three to five years.

An upland and lowland site has been chosen for a perpetual source of seed and to test whether separate ecotypes for this species exist. To date, the stands have been chosen and some cones collected from dominant trees in the stands. The plan includes cone collection during each good cone crop year and testing of the seed and seedlings.

Two farm-field tests of first generation breeding populations are now in progress. One test has been planted and assessed on first-year height. The second test is to be assessed for the first time in the fall of 1991. The objectives are (a) to provide high quality genetic information to supplement field test data, (b) screen families for use in the clonal program, (c) derive age-age correlations, and (d) compare seedlings grown from controlled cross seed with those from plus tree seed.

The clonal program has been reviewed and changes made to provide a more desirable steckling for shipping; as well, a new intermediate five step process for testing material has been implemented.

Jack Pine

A genecology study is planned for 1991 in cooperation with Northeastern Region (Great Lakes). The objectives are similar to those for the black spruce study. Assessment information from three family tests was used to rogue 30% of the trees from the Aidie Creek Seed Orchard.

A cone monitoring system to evaluate flower and cone development and seed production is being tested in two orchards. Seed orchards for both species will have fertilizer calibration trials established in 1991. In addition, a number of other studies are in progress; these include: pollen distribution and contamination, fertility management using DRIS, insect and disease monitoring, and climate mapping. Some seed orchards have also been equipped with weather stations and computer facilities.

Breeding Hall

The breeding hall continues to be the centre for service and support for the program. New trials concentrate on breeding techniques and contamination, pollen collection and processing, small seedlot extraction and testing, and induction of male flowers. Other trials, such as black spruce plagiotropes, graft overwintering techniques, and fertilization are coming to a close.

NORTHEASTERN REGION

NORTH SHORE TREE IMPROVEMENT COOPERATIVE

The North Shore Tree Improvement Cooperative was formed six years ago. The members of the cooperative are Domtar Inc. in White River, Dubreuil Forest Products in Dubreuilville, E.B.Eddy Forest Products in Espanola, St. Marys Paper Inc. in Sault Ste. Marie, and Ontario Ministry of Natural Resources in Northeastern Region. The cooperative has expanded to include all species in the Region. Companies are currently involved with the jack pine and black spruce programs. OMNR is currently the sole participant in the white spruce and white pine programs.

Jack Pine

Since the last report, two seed orchards and five family tests have been established. This completes the establishment of the seven seed orchards and 19 family tests of the first generation program. Most of these were established in the early 1980's by OMNR and responsibility for some areas has been transferred to company members. Domtar Forest Products has responsibility for two tests and a seed orchard. Dubreuil Forest Products has responsibility for a seed orchard. E. B. Eddy Forest Products has responsibility for a seed orchard and three family tests. The remaining four seed orchards and 14 family tests are the responsibility of OMNR. Fifth-year measurements were taken on most of the family tests in the fall of 1989.

In the spring of 1991, seventh-year height measurements were taken on one of the seed orchards and three tests. This assessment along with fifth-year assessments will be analyzed for the purpose of roguing the orchard this fall. Seventh-year assessments in other family tests will take place this fall in preparation for roguing additional orchards in 1992.

Black Spruce

A seedling seed orchard and three family tests for breeding zone 4200 were established in 1989. The seed orchard consists of 400 families planted in a 4-tree cluster design. Family tests are planted in randomized single-tree plots in 32 replications. St. Marys Paper Inc. jointly manages this seed orchard with Sault Ste. Marie District. Initial survival in this orchard was very poor (60%); however, a major refill plant in 1990 has remedied this. In breeding zone 3200 a seedling seed orchard and two family tests were site prepared and are being planted in 1991.

White Pine

Three clonal seed orchards are planned. Field grafting has been the method used for establishing white pine orchards. The orchard for the 5200 east breeding zone is complete. About two-thirds of the 5200 west orchard are complete, and the third orchard for breeding zone 4200 has been site prepared for planting beginning in 1991.

White Spruce

A clonal seed orchard has been started for breeding zone 4200. The permutated neighbourhood design is used in all clonal seed orchards in the Region. Two hundred of the 216 clones for the orchard have been grafted, but only 30 clones have been outplanted so far. Establishment is scheduled for completion in 1993.

ALGONQUIN REGION

White Pine

The establishment of three 8-ha clonal seed orchards for the Petawawa source is complete. Surplus grafts were either planted into additional blocks or into areas adjacent to seed orchards. Many grafts in the breeding orchard in Pembroke District produced female flowers. Controlled pollination for progeny testing was started in the spring of 1990, using a polycross mating design. First season results showed that pollination was successful. The developing conelets were protected with screen-bags. They will be picked in the fall of 1991. More crosses are scheduled for the spring of 1991.

More plantings were carried out in the Georgian Bay source seed orchard. Establishment was largely completed in the spring of 1991.

White Spruce

Due to the dry site in the upper Ottawa Valley white spruce clonal orchard, numerous grafts, though small, produced a heavy crop of cones. The 1000 cones picked to investigate seed yield showed an average of 35 seeds per cone. In view of the small quantity of pollen produced in the orchard at this stage, some external infusion of pollen was suspected. Due to a change in mandate at PNFI, 142 additional grafts of the same source were transplanted into this orchard in 1990.

Tamarack

In an attempt to increase the number of donor plants from superior trees for rooted cutting production,
crosses were carried out among 18 clones in the seed orchard in 1990. The resulting seeds were grown to produce donor plants. The 1000 cones picked in 1989 to investigate seed yield showed an average of 0.35 seeds per cone. However, controlled pollination improved the yield somewhat to 1.75 seeds per cone. If flower production warrants it, more crosses will be made in 1991.

Red Spruce

Establishment of the seed orchard began in 1990 and was largely completed by 1991. The grafts, which were under-planted among residual red spruce trees, showed good survival and growth. Access and fire protection of the seed orchard were improved in 1991. Grafts of each clone will also be established in a breeding orchard, at a different location in the Region.

CENTRAL AND SOUTHWESTERN REGION

White Pine

Establishment of the 24-ha 6E white pine clonal orchard was completed in 1991.

Though containing 260 clones, the 6E breeding orchard produced no female flowers in 1990, thus precluding any controlled crosses for progeny testing. Subsequently, 23 clones were selected and sprayed with a solution of GA 4/7 to induce flower production. Weekly sprays of the chemical solution were carried out from August 15 to September 18, 1990. All treated branches were marked for assessment in the spring of 1991. If the response is positive, controlled pollinations will be carried out to produce seed for progeny testing.

Establishment of the 7E white pine clonal orchard in Niagara District was completed in 1991. Surplus grafts were planted in an area adjacent to the seed orchard.

The 7E white pine breeding orchard in St. Williams Nursery produced an abundant crop of female flowers in 1990. Controlled pollination was done for progeny testing on 30 clones using a polycross design. First season results indicate that pollination was successful. The developing conelets were protected with screen bags and will be harvested in the fall of 1991. Additional crosses are being scheduled for the spring of 1991.

Black Walnut

All available plus tree grafts have been outplanted into the production/breeding orchard at the St. Williams Nursery. One hundred selected seedlings of black walnut from the outplanting trial in the nursery were inter-planted among the grafts to supplement seed production in future years.

White Ash and Red Oak

Selected seedlings of both white ash and red oak from St. Williams Nursery were used to set up a demonstration/seed production area in Chatham District in the spring of 1991.

Crop Monitoring System

In order to manage cone crop production more effectively, for both planning and budgeting purposes, a cone crop monitoring system was set up in the blister rust white pine seed orchard at Orono Nursery in 1990. Three hundred and sixty female flowers on ten sample trees were individually tagged and numbered. Their survival and development are being followed through periodic inspection and recording. To date, two observations have been made and a third one is scheduled for the spring of 1991.

W.R. BUNTING TREE IMPROVEMENT CENTRE, ORONO NURSERY

The W.R. Bunting Tree Improvement Centre, located at Orono Nursery, continues to support the tree improvement programs of Central, Southwestern and Algonquin Regions.

Norway Spruce

Four genetic tests of Norway spruce rooted cuttings have been established over the past two years. These field tests are designed to yield information on family and clonal performance in outplantings in southern Ontario. This data will be used to manage the genetic composition of the donor plants used in the production of Norway spruce rooted cuttings.

A series of Norway spruce rooted cutting demonstration plots is being established across southern Ontario. Three plots are now in the ground and four more are planned for 1992. These plots will compare rooted cutting performance among clones and between cuttings and seedlings.

European Larch

Two greenhouse trials are under way in European larch rooted cutting production. One of these trials examines how the age of donor plants affects the rootability of cuttings and their ultimate form. The other examines a variety of growing regimes to see which yields cuttings of most desirable size and form. It is hoped that these trials will give us the information needed to eliminate the plagiotropism we have noticed in this crop.

Tamarack

Tamarack seed resulting from controlled crosses in an Algonquin Region orchard were germinated and the resulting seedlings are being managed for cutting production. This will improve the genetic quality of the tamarack rooted cuttings produced at the Centre.

Accelerated Breeding

Trials in flower induction, accelerated growth of grafts and pollen germination are planned or are now being carried out. These trials concentrate on white pine and Norway spruce. White pine tests are designed to yield information that will accelerate the field-based breeding programs so that progeny testing can begin sooner. The acquisition of a precision seeder and the construction of another polyhouse have expanded and improved our growing capabilities in anticipation of growing white pine progeny test stock.

EASTERN REGION

White pine

Establishment of one of two white pine clonal seed orchards was completed over the 1990 and 1991 planting seasons. The orchard is located at Taylor Lake in Carleton Place District. Woven polypropylene mulch was applied for weed control and moisture retention. Site preparation of the second orchard site at Kemptville Nursery was initiated in 1990 and planting will commence in 1992. A rodent repellent was applied in the fall of 1990 to prevent stem girdling from rodents during fall and winter.

Flower induction development trials to test injection and foliar applications of GA 4/7 have been continued. Although techniques to induce pollen on white pine grafts are now established, consistent results for females have not yet been achieved.

The breeding strategy for white pine consists of a polycross to determine breeding values for plus trees. Pollen was collected in 1989 and 1990 and stored as a backup for the polycross in the event that fresh pollen is not available. Pollen was obtained by collecting branch material from selected polycross trees then maintaining branches in a greenhouse until pollen was ready to be collected. This technique worked very well in both years.

Norway spruce

The breeding strategy for Norway spruce is dependent on a potted breeding orchard. Development efforts were concentrated on techniques to accelerate growth of grafts and to induce flowering. Results of 1990 flower induction trials were very positive with stem injections of GA 4/7 resulting in an increase in female flowers and heat application resulting in an increase in the production of male flowers. A short term nursery screening test was established in 1989 to screen clones as donors for the Norway spruce vegetative propagation program. This test will also serve as a basis for determining a management strategy for short term tests in the future.

Larch

Tree improvement programs for native tamarack, Japanese larch and European larch consist of plus tree selection, potted breeding orchards, and vegetative propagation. Flower induction trials implemented in a soil based hybrid larch orchard resulted in increased pollen production in European larch in response to downward branch bending. Forty controlled crosses were completed in a hybrid larch orchard in 1989 utilizing pollen from European larch to pollinate females on Japanese larch. The progeny produced will be utilized for testing purposes as well as stock for the vegetative propagation program. A branch bending trial implemented in 1990 on Japanese larch also showed an increase in pollen production.

GENETICS, GENECOLOGY AND BREEDING IN THE GENUS *PICEA* L. (SPRUCE)

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Keywords: *Picea*, genecology, genetic variability in spruce forest ecosystems, interspecific hybridization, gene pool conservation.

The objectives of these studies are: (1) to quantify genotype x environment interaction as part of a breeding strategy for selecting desirable spruce genotypes for maintaining genetic variability and diversity in spruce forest ecosystems, and for developing valuable hybrids for 'new forests' under changing environmental regimes; (2) explicitly, to investigate G x E interaction by determining genetic variation in efficiency, growth and nutrition and productivity as related to site regions, breeding zones etc., utilizing the *Piceta* as outdoor laboratories; (3) to create long-term genetic banks for gene pool and population studies, breeding and assessment of genetic parameters to elucidate the breeding system and structure of the genus *Picea*; (4) to produce, test and select the best hybrids for propagation; (5) to utilize the arrays of spruce species and genotypes located in the *Piceta* for long-term monitoring of forest health as related to possible airborne pollution and/or climatic change.

HYBRIDIZATION

Following a massive flowering in spruce in Ontario in 1988 flowering in 1989 was astonishingly still more massive. Breeding was carried out in our *Piceta* in Sault Ste. Marie and Simcoe Districts in the mid-north and south respectively. Four hundred and twenty-nine tree x pollen parent crosses were made with replication by 777 ramets. There were 162 interspecific crosses involving 30 species and 4 additional forms. Twenty of these species were used as females while 29 were used as males. There were, in addition, 4 tri-and quad-hybrid crosses, 2 hybrid backcrosses and F1 crosses.

Many confirmation crosses and a moderate number of new crosses were made with both positive and negative, expected and unexpected results. Some highlights are noted. Following work reported (Gordon 1989) on *Picea koyamai* and *Picea koraiensis* and their relationship to *Picea asperata*, reciprocal crosses were made with several other Chinese and Japanese species. Both *P. koyamai* and *P. koraiensis* crossed readily with *P. montigena*, *P. retroflexa* (almost as easily as with the controls) and with *P. meyeri*. *P. koyamai* failed with *P. wilsonii*, *P. likiangensis* and *P. bicolor*. *P. glehnii*, which may prove to be a bridging species, crossed moderately well with *P. koyamai*, *P. meyeri*, *P. abies*, *P. asperata*, *P. wilsonii*, with low crossability *P. likiangensis*, and surprisingly with *P. schrenkiana*. These crosses are, however, yet unconfirmed. *P. obovata* and *P. rubens* sparingly also crossed with *P. glehnii*.

Fowler(1966) described the first cross of *P. schrenkiana* and *P. glauca*. While confirming that cross, we have attempted many species combinations with *P. schrenkiana* and have found it to be an extremely rigid species. In 1989 it failed consistently to cross with *P. asperata, P. koraiensis, P. koyamai, P. mexicana, P. meyeri, P. montigena, P. omorika, P. orientalis* and *P. retroflexa*.

New crosses were successful with *P. wilsonii* x *P. maximowiczii*, good crossability; and *P. wilsonii* x *P. glehnii* and *P. likiangensis* both of low crossability. Successful new crosses were also obtained between *P. mexicana* x *P. orientalis, P. koyamai, P. jezoensis* (reciprocally) and *P. bicolor*, all with low or very low crossability.

Three successful quad-hybrid crosses demonstrated ease of extended hybridizing within their own group and a negative propensity for tri-hybrid crossing outside their group. Hybrids *P. mexicana* x *P. engelmannii, P. mexicana* x *P. glauca* and *P. mexicana* x *P. rubens* all crossed relatively easily with x *P. lutzii* (*P. sitchensis* x *P. glauca*) while hybrid *P. mexicana* x *P. rubens* repeatedly failed with *P. meyeri*.

Following the massive flowering in the preceding two years a hiatus in 1990 was inevitable. Only 62 tree x pollen parent crosses were made utilizing 115 ramets. There were 31 interspecific crosses involving 25 species and one form.

Results were mostly negative. However, successful confirmation crosses were obtained for *P. glehnii* with *P. asperata* and *P. koyamai* with moderate crossability, and with *P. abies*. A new cross was *P. rubens* x *P. purpurea* of low crossability and as yet unconfirmed.

GENETIC HERITAGE/GENE POOL CONSERVATION

In collaboration with the Centro de Genetica Forestal, Mexico and the support of the North American Forestry Commission I carried out field work in the late winter and early spring of 1990 at high elevation sites in Nuevo Leon in northeastern Mexico, and Durango and Chihuahua in western Mexico. This work consisted of sampling and evaluating populations of relictual Mexican spruce species and doing site assessments.

The main station of one of these species, *Picea mexicana*, had been decimated by fire some 15 years ago. Ten thousand hectares were destroyed and almost all of this species lost. We were able to locate only about 250 scattered immature and mature survivors.

Our original seed collection from this stand dates from 1963, well before the fire. As a limited aid to restoration of the species, we are developing groups of clones of the trees from that collection, which, when ready, will be returned to Mexico for planting at selected locations in the burn.

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CONE INDUCTION AND TISSUE CULTURE STUDIES

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CONE INDUCTION

Potted 3- and 5-year-old grafts of black spruce (*Picea mariana*) growing in either a heated greenhouse or an outdoor holding area were sprayed weekly at different concentrations of gibberellin $A_{4/7}$ ($GA_{4/7}$) for various durations and timings. The grafts sprayed at 200 $mg.L^{-1}$ during the period of lateral shoot elongation produced significantly more seed cones but not pollen cones while spraying initiated after the elongation did not promote any cone production. The best response in seed-cone production occurred when application began two weeks after bud break and continued for five weeks; treatments were also effective when application began three weeks after bud break or earlier and continued for four to six weeks.

Potted grafts of eastern white pine (*Pinus strobus*) were sprayed with three different concentrations of $GA_{4/7}$ for four different periods; each consisted of six weekly applications from mid-May to mid-September. $GA_{4/7}$ at 250 and 500 $mg.L^{-1}$ were effective in promoting both pollen- and seed-cone production at two different periods. Spraying in May and June, prior to bud-scale initiation of potential pollen-cone buds, was most effective for pollen-cone production and spraying in August and September, prior to bud-scale initiation of potential seed-cone buds, for seed-cone production.

EXPLANT CULTURE OF BLACK SPRUCE

Plantlets have been produced from rooting of adventitious shoots which were regenerated from embryonic shoots. The embryonic shoots were cultured on LP medium supplemented with benzylaminopurine (BAP) and naphthaleneacetic acid (NAA) to induce organogenesis of adventitious shoots, and the latter was then cultured on LP medium without any supplement for adventitious shoot elongation. The shoots were cut from the cultured embryonic shoots and pulse-treated with indolebutyric acid for rooting; the shoots were then rooted in one-half strength of LP medium without any supplement. Plantlets were transferred but did not survive in soil.

SOMATIC EMBRYOGENESIS OF SPRUCES

Embryogenic calli have been induced from mature zygotic embryos of black, white (*P. glauca*), and blue spruce (*P. pungens*), and somatic embryos have been produced only in black spruce. Mature embryos were cultured on LP or LM medium, each supplemented with BAP and 2,4-dichlorophenoxyacetic acid or NAA for three months. Embryogenic calli were often regenerated from the calli of the cultured embryos in the second month of culture. Embryogenic calli are translucent and have many suspensor-like cells, each suspensor with an early embryo. The calli with early embryos of black and white spruce were cultured on LP or LM medium, each supplemented with abscisic acid (2 $mg.L^{-1}$), for four weeks, and then transferred onto the medium without any supplement for embryo maturation. Embryo maturation occurred in black spruce but not in white spruce, and the embryos could be cultured to produce plantlets.

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TREE GENETICS AND IMPROVEMENT

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Keywords: early selection, selection index, growth curves, physiological genetics, seed collections, pollen

INTRODUCTION

The genetics project at PNFI experienced another year of 'change'. Tim Boyle left us after 9 years for a new career as scientific coordinator (Genetic and Biodiversity) at Forestry Canada's Headquarter in Ottawa. A new research scientist, Kurt Johnsen, was hired in 1990 to begin studies of physiological genetics. Involvement in the CIDA ASEAN FOREST TREE SEED CENTRE project in Muak Lek, Thailand continues at a significant level. Development of Facilities for physiological studies (growth chambers and laboratory equipment) are given priority. Integration of the genetics program at PNFI to a Forest Genetic Resources and Biodiversity Centre is underway.

PROVENANCE/POPULATION STUDIES

Periodic measurements are continued in more than 100 provenance/population studies of jack pine, black spruce, Norway spruce, white spruce, and Tamarack. Summary reports on major findings are planned to appear during the next 3-4 years.

An evaluation of several black spruce population/progeny tests in northern Ontario revealed a highly significant and unstructured genotype x environment interaction. No classical way of analysis could shed light on the results. A new evaluation based on careful screening of the data after a site inspection is being considered.

Growth curve techniques were successfully used in a cooperative (FC Maritimes) study of Japanese larch.

A seed collection trip to Siberia in 1990 resulted in about 68 seedlots from 10 provenances. Seed will be made available to provincial agencies and for genetic research.

PROGENY TESTING

The contrasting performance of black spruce families from a 7-tree diallel on three sites was examined further in a nursery trial with controlled water supply. Preliminary results indicate similar growth patterns in the nursery and in the older field trials. Differences in drought tolerance is the conjectured cause for the genotype x environment interactions.

Norway spruce trials (half- and full-sibs) of progenies originating from a single plantation at PNFI (Hudson's Place) indicated a superiority in height and diameter of this land-race material compared to the best provenances in a nearby IUFRO trial from 1939. Strong genetic control was demonstrated for weevil tolerance and frost hardiness, while heritability estimates for height and diameter were comparable to those for other species. Gain potential in the land-race may have decreased due to several generations of selection.

A jack pine half sib family trial growing on three sites in the Ottawa Valley was evaluated at age 6 and 14 for height and diameter growth. Genetic control was favorable for generating genetic gain; genotype x environment interactions were weak. Selection based on an index combining family, block, plot and tree information was more efficient than either mass selection or a combined family and within-family selection. When wood quality parameters (density, taper, heartwood content) were evaluated we concluded that an unrestricted selection for wood volume would be the best strategy because no concomitant detrimental effects of economic significance could be expected in the quality parameters by adopting this strategy.

A new image analysis system has been implemented and is now used for tree ring analysis of our older progeny tests.

BREEDING

Selections of black spruce, jack pine, and Norway spruce for advanced generation breeding are made on an ongoing basis. A new pollen extraction facility has been inaugurated and technical notes on pollination techniques have been published. A breeding project for a study on in-situ adaptation in black spruce is well underway. Crosses between populations from Moosonee, Petawawa, and Turkey Point will be completed within a year or two.

SELECTION PROCEDURES

Work continued on the development of decision support models for early selection. The use of deterministic simulation, Markov chains, time series, stochastic dominance theory (coop with B.C. Min. of Forests), and bootstrapping has been exploited as tools for predictions and assessment of risk.

New developments in index selections include an algorithm for maximum simultaneous gain, the use of non-linear profit functions and continuous selection indices (based on growth curves).

SPATIAL EFFECTS

Had any experience with those irritating significant spatial autocorrelations? Well, they probably exist in most forest genetics trials. We have investigated some spatial models that might mitigate the effect of the underlying microsite effects. Don't expect too much from them, but they are worth exploring.

PHYSIOLOGICAL GENETICS

Controlled environment studies with enhanced CO2 and contrasting nutrient levels have been initiated with black spruce seedlings and 'emblings'. An intensive monitoring of gas-exchange and water relations in a black spruce 7-tree diallel is planned for this year. Shoot growth component analysis of this diallel will compliment the physiological measurement and elucidate the mechanisms behind the observed growth differentiation. Researchers at U. of T. have found marked differences in drought tolerance and adjustments to drought among a subset of the diallel families.

DATA MANAGEMENT

Information on field computers in North America has been compiled and published. Our experimental maps are now being produced with digitizing technologies (ARCH-INFO). The experimental data-bases have been transferred to INGRESS.

ASEAN FOREST TREE SEED CENTRE PROJECT

The genetics project has been providing professional and technical expertise to this project in areas such as: Isozymes (techniques and analysis), genetic conservation, tree improvement, design and analysis of experiments, personal computers, data-bases, field computers.

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NATIONAL TREE SEED CENTRE
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Keywords: Seed germination requirements, seed maturation, seed storage, IDS, flower induction, seed production, cone and seed insects.

INTRODUCTION

The National Tree Seed Centre continued to conduct basic and applied research and development on seed quality and seed production and to provide services to the international, national, and regional forestry communities. In the future the structure of the Centre will undergo change as a newly proposed project on National Genetic Resources and Biodiversity is developed and established. The following are highlights of the Seed Centre's activities for the last two years.

RESEARCH AND DEVELOPMENT

Seed Quality

Seed Maturation: This study on white spruce was initiated from 1984 in cooperation with Dr. Guy Caron of the University of Moncton. Our results from the 1984 crop clearly suggested that seed germinability of mature white spruce from a small plantation at Petawawa Forest, Chalk River, Ontario, was enhanced by 6-week post-harvest cone-ripening and that prechilling significantly improved both the rate and total germination. However, a repeated study from the same plantation in 1988 showed completely different results. This points out the importance of yearly variation in forest trees and stands, and the danger of drawing general conclusions from a research on a single stand in a single year.

Upgrading seed quality: Bruce Downie joined our research team in November 1989 and made important headway in developing methods for upgrading seed quality. The IDS (Incubation, Drying, and Separation) technique for separating filled-dead from filled-live seeds is useful for upgrading seedlots of mediocre quality for container seedling production. The technique has been evaluated on balsam fir, jack and lodgepole pine, and white spruce in cooperative research work with the Alberta Forest Service and the Swedish Univ. of Agricultural Sciences.

Effect of processing on Seed Germinability & Vigour: Results of cooperative research with the Alberta Forest Service indicated that seed germinability and vigour of lodgepole pine from Alberta is affected by high kiln temperature and kiln design. A critical consideration for establishing protocols in processing germplasm material for long-term gene conservation storage.

Prechilling Effect on Black Spruce Seed Germination: Experiments on black spruce seeds indicate that, while they are not dormant, their germinability and germination rate are greatly accelerated under sub- (10-15°C) and supraoptimal (35°C) temperatures compared with the controls, if the seeds have undergone prechilling for 2 weeks. A cooperative research study, focusing on white spruce, with the Alberta Forest Service and Ontario Ministry of Natural Resources will determine the effect of seed moisture content on prechilling and prechilling methods for standardization in nursery practice.

Seed Treatment: Osmotic invigoration was studied with jack and lodgepole pine, and white and black spruce seedlots. Our results indicated that the effect of osmotic invigoration with PEG on the germinability and rate of germination varied with seedlot and species and its effect was most pronounced with seedlots of mediocre quality.

Seed Storage: The Accelerated Aging technique by exposing seeds to 40°C and 98% and R.H.for seed vigour testing or predicting seed storability potential has been standardized for lodgepole, jack pine, and white and black spruce seedlots. The technique is being widely used for other species. Studies on cryopreservation of black and white spruce seeds showed that seeds of both species were stored successfully in liquid nitrogen of -196°C for 4 days without any ill effect on seed germinability or vigour. Following removal from cryopreservation storage, seeds of both spruces can be safely thawed quickly in 40°C warm water for 90 seconds or slowly at room temperature (22°C) for 90-120 minutes. A literature review of cryopreservation of seeds was completed and is under review. A joint review for FAO on possibilities and limitations of storage of seed, pollen, and tissue as an alterative to in situ genetic conservation will be completed by July 1991.

Seed Production

Cone crops and insect damage: Examination of data on tree protection and cone production of white spruce seed trees treated with soil applied ammonium nitrate and carbofuran indicated that carbofuran protected black and white spruce trees from budworm defoliation for two years following treatment. Cabofuran-treated white spruce trees produced significantly more female cone buds compared to controls for three years following treatments. A seven-year study monitoring Upper Ottawa Valley spruce cone crop size, cone damage by insects, and population monitoring of the spruce seedmoth by means of sex attractant lures indicated that cone crop size is negatively correlated with cone damage by insects. Higher than normal summer temperatures are followed in the subsequent year by large cone crops, low incidence of seedmoth diapause, and high seedmoth mortality (Fogal 1989). In a related study, cone seed yields and insect damage were sensitive to white spruce community structure. Observations on seed development revealed that 9 - 16% of seeds developed to the mature embryo stage, 24 - 30% aborted, 23 - 29% were lost to insects, and 32- 35% of losses could not be identified (Fogal and Larocque 1991). A review of field trials of systemic insecticides for potential use against cone and seed insects of northern spruces and pines was published (Fogal and Plowman 1989).

Flowering and seed production: A three-year cooperative field trial with Weyerhaueser Canada, Saskatchewan Division to test ammonium nitrate and gibberellin applications to enhance flowering and seed production of jack pine seed orchard trees is near completion. Soil and tree nutritional status play an important role in ability of trees to respond to treatments. A four-year study to determine the effects of topping on flowering, seed production and growth of nine-year-old jack pine seed orchard trees is near completion. A two-year cooperative field trial with the Quebec Ministry of Energy and Resources to assess injection and implant formulations of gibberellins for increasing flowering and seed yields of Norway, white spruce and jack pine is near completion. Results of a preliminary study with a single family of five-year-old potted jack pine trees indicated that nitrogen supply plays a major role in the expression of sexuality. Nitrogen deficiency resulted in abundant production of male flowers whereas with luxury levels, very small numbers of males were produced. For female flowers reverse effects of nitrogen were observed but the magnitude of the effects was not as great as for males. This experiment was repeated on a wider genetic base of ten families. Trees were grown under accelerated growth conditions for 16 months and then treated with varied nitrogen supply and gibberellin sprays. The effects of nitrogen were essentially the same as those observed with five-year-old trees. With appropriate combinations of cold treatment, nitrogen supply, and gibberellin application, up to 80% of trees produced female flowers and 30% produced male flowers in 28 months from seed. Seed production by these trees will be assessed in 1991.

SEED BANK AND SERVICES

Seed Procurement and Processing

The Seed Bank procured 280 seedlots of about 35 species from various regions in Canada and other countries through collections by Project staff and cooperators, seed exchange, and collaborative research projects. The Seed Bank now is stocked with 2400 seedlots of 200 species.

The Centre's Seed Extraction Plant processed near 1300 lots of 25 species for the Seed Bank, other Institute Projects, and outside research cooperators.

Information and Seed Requests and Seed Testing

In response to over 280 requests for seeds for research purposes, 1000 seed samples were shipped to clients in Canada and 23 other countries. Many requests for information on seed availability and seed technology were answered to clients' satisfaction. It is interesting to note that there has been a growing demand for sugar maple seeds in the last couple years.

Although no regulatory test has been performed, over 2400 in-house and other service tests were conducted for purity analysis, germination, and determination for seed moisture content and 1000-seed weight. One of the tests was a referee testing of Pinus sylvestris organized by the International Seed Testing Association. Bea Kelley who is in charge of the seed testing attended a one-week Agriculture Canada Seed School in Toronto.

TECHNOLOGY TRANSFER

Ben Wang continued to serve as the Scientific Coordinator and Seed Technology Advisor for CIDA's ASEAN-Canada Forest Tree Seed Centre Project in Thailand. Hugh Schooley continued to act as the editor of the CTIA Tree Seed Working Group News Bulletin. Current ongoing cooperative research with universities, provincial forest services and forest industries continues to provide excellent opportunities for technology transfer.

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MOLECULAR GENETICS AND TISSUE CULTURE AT PNFI

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The Molecular Genetics and Tissue Culture Project at PNFI focuses on aspects of biotechnology that can assist and contribute to the genetic improvement of intensively managed forests by accelerating certain steps. The project is also increasing its activities in the use of biotechnology for germplasm preservation and for the characterization of genetic biodiversity of forest tree species such as by RFLP mapping and fingerprinting.

In the area of Cell and Tissue Culture, research on conifer species is in progress to identify factors involved in the induction of embryogenic callus of mature and immature zygotic embryos; to increase the numbers of somatic embryos; to prolong long-term maintenance of callus and cell lines; to understand the processes involved in somatic embryogenesis; to assess the genetic stability of plants obtained from somatic embryos; and other studies. Experiments are also in progress for the *in vitro* propagation of some economically important deciduous species. Embryogenic cell lines are maintained for hybrid larch, Japanese larch and European larch, black spruce, red spruce and white spruce. Conditions for optimal embryogenesis were defined for each species. Protoplasts recovered from hybrid larch embryogenic cell suspensions were regenerated to give whole plants. Collaborative studies with INRA are being done to accelerate the process of somatic embryogenesis in conifers and to develop new protocols for embryo desiccation. Plants from embryogenic cell lines of black spruce (emblings) are being field tested in collaboration with the Tree Genetics and Breeding Project. Cryopreservation facilities will soon be established. Collaboration with U. of Guelph and J.D. Irving Ltd. is in progress to upscale somatic embryogenesis of black spruce. Insect feeding experiments have been initiated with FPMI using poplar cell culture material.

Some of the newer techniques in biotechnology are being used to establish a basic understanding of woody plant gene function, expression and function. PCR (polymerase chain reaction) together with DNA sequencing is being used to isolate and characterize certain structural genes and novel classes of "regulator" genes that are involved in the control of gene expression and cellular development. Results with chalcone synthase indicate that for black spruce it is part of a large multigene family. Results with some of the genes that are involved in regulating flowering; anthocyanin production; and other processes, also show that they are part of a large multigene family. Southern and northern hybridizations are in progress. Further studies will involve promoter structure and function for these genes. In co-operation with Dr. J. Carlson (UBC), results of one experiment using RAPD, a new PCR-based technique for rapid genetic mapping, have been sent for publication. Other fingerprinting techniques are also being used to assess and map genetic variation in the tree populations and somaclonal variation during tissue culture. One study has been completed to examine larch tree mitochondrial genome (mt DNA) structure and inheritance, and to determine if rearrangement of mt DNA is occurring during tissue culture and protoplast regeneration of larch. Another study has been completed together with BC Research that involved determining if genetic variation was being induced during somatic embryogenesis. Initial results with isozyme studies have revealed no variation, and further studies are continuing using RFLP techniques. A collaborative study with Br. Bong Y. Yoo of UNB has been completed in which changes in protein patterns by electrophoresis and enzyme activities were monitored during somatic embryogenesis of hybrid larch.

In the area of Genetic Engineering research, some of the goals include the developing of reliable protocols for the routine transformation of woody plant species; the study of gene regulation and expression and for the introduction of new and biologically valuable traits following transfer of new genetic information; collaboration with other groups; and to examine various environmental concerns dealing with the release of transgenic trees. In initial experiments, protoplasts of larch were used in the development of a transient-expression system using electroporation, for gene expression studies. Transient expression of gene markers (eg. CAT and GUS) was obtained and optimal conditions established. With the leasing of a microprojection apparatus from Dupont, gene transformation work was initiated in hybrid larch and black spruce by Dr. Luc Duchesne. Using the GUS gene marker, conditions for optimal delivery have been determined. Microprojection work is also being done with hybrid poplar by a graduate student (Y. Devantier). Genetic engineering of hybrid poplar is continuing using both *Agrobacterium tumefaciens* and *a. rhizhogenes* transformation. Collaborative studies are in place with INRA in France. Recently Dr. Marie Anne Lelu spent 4 months at PNFI to pursue tissue culture experiments.

In terms of staff three new members joined the molecular genetics group; Christopher Kauffeldt, a technician; Glen Sunohara, a biologist; and Dr. R. Rutledge, a research scientist.

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ONTARIO TREE IMPROVEMENT COUNCIL - PROGRESS

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The Ontario Tree Improvement Council [OTIC] is an industrial / government cooperative responsible for implementing a number of tree improvement projects in Northern Ontario. The projects are designed to meet the need for improved seed for the reforestation programs of the future.

Operational black spruce [*Picea mariana* [Mill.] B.S.P.] and jack pine [*Pinus banksiana* Lamb.] tree improvement projects have been established in the four Northern Regions of the Province. The members have selected over 3000 plus trees, established 144 hectares of seedling seed orchard and planted 26 family tests in various breeding zones. Funding for the establishment and management of these projects now comes totally from member agencies. In the past, partial funding came from the Canada-Ontario Forest Resources Development Agreement. OTIC employs a Regional Tree Improvement Specialist and a Seed Orchard Manager to provide support to the cooperating members. Progress has been excellent and has every prospect of continuing.

OTIC MEMBERS, OBJECTIVE AND STRUCTURE

OTIC is an incorporated cooperative composed of Abitibi-Price Inc., Boise Cascade Canada Ltd., Canadian Pacific Forest Products Ltd., Malette Inc., Quebec and Ontario Paper Co. Ltd., and the Northwestern, North Central, Northeastern, and Northern Regions and the Forest Resources Group of the Ontario Ministry of Natural Resources [OMNR].

The objective of OTIC is to increase the supply of roundwood available to the forest industries of Ontario by fostering the cooperative approach to a tree improvement program which will shorten rotations, increase yields and improve wood quality. OTIC is meeting this objective by (1) ensuring that all seed used in the reforestation program is well adapted and source identified, and (2) providing genetically improved seed through a program of plus tree selection, testing and seed orchard establishment.

OTIC is structured into two levels of committees. The Board Of Directors, composed of a senior management representative from each of the ten agencies, is responsible for setting policy, providing guidance to the Director and approving a yearly budget. A Regional Working Group is in place for each tree improvement project and is composed of foresters responsible for tree improvement from the industrial woodlands offices and OMNR Regions and Districts involved. The Working Groups plan the projects, distribute the tasks, approve a budget, and are responsible for the implementation of each project.

PROGRESS OF PROJECTS

OTIC was formed in 1985, by which time the OMNR had established tree improvement programs over much of the Province. OTIC projects were designed to complement those of OMNR's in areas or species where OMNR had no program and where OTIC industrial members had responsibility for forest management.

The strategies for improvement of both black spruce and jack pine are those outlined in the OMNR document "Tree Improvement Master Plan For Ontario" [1987]. Plus trees are extensively selected (i.e., sampling the population with the best available trees); cones and scions are collected; seedling families produced; and family tests (32 replications of single tree plots) and seedling seed orchards (x blocks of single tree plots) established. Seed orchards will be rogued based on family test results. Breeding orchards are also established from grafted material.

Northwestern Region

Boise Cascade of Fort Frances, Canadian Pacific F.P. of Dryden, the Fort Frances and Dryden Districts and the NW Region of OMNR are cooperating to improve jack pine in two breeding zones. In the Fort Frances area, OMNR and Boise Cascade established a 10 ha. seedling seed orchard and three family tests in 1989. Survival has been excellent, management has been intensive and growth has been superb. In the Dryden area, Canadian Pacific and OMNR jointly established a 12 ha. seed orchard and three family tests in 1989. One test was destroyed by deer browsing the first winter but the other installations are progressing well. The OMNR Dryden nursery is presently establishing a breeding orchard containing three ramets of each plus tree from both projects.

The OTIC industrial and government members contributing to both the Northwestern and North Central Regional projects have pooled resources to employ a full time Regional Tree Improvement Specialist to provide coordination and support for their programs.

North Central Region

Two cooperative projects, in different stages of development, are ongoing in this Region. In a large breeding zone to the west of Lake Nipigon, Abitibi-Price, Canadian Pacific F.P., both of Thunder Bay, and the Regional and Thunder Bay District offices of OMNR are cooperating to improve both black spruce and jack pine. Abitibi-Price and OMNR have each established a 16 ha. black spruce seedling seed orchard while Canadian Pacific has established a 14 ha jack pine orchard. The OMNR black spruce orchard has been plagued with severe grass competition while the C.P.F.P. has suffered from heavy deer browsing, however, an electric fence with a moat has reduced the problem. Four family tests of each species have been distributed across the breeding zone although two of the tests have been lost to inimicalities. Despite intensive prevention efforts, up to 40 percent of the individuals in the jack pine tests have been damaged by either the white pine weevil or the jack pine shoot borer. This may limit the quality of genetic information produced.

In the breeding zone to the west of Thunder Bay, Canadian Pacific F.P. and the Regional and Atikokan and Thunder Bay Districts of OMNR are cooperating to improve both black spruce and jack pine. Plus tree selection which began in 1988 has now been completed. The black spruce orchard and tests were established in the spring of 1991 while the jack pine project will be established in 1992. The 14 hectare black spruce seed orchard was planted by OMNR on a recently purchased farm tract and the three associated family tests were planted by

Canadian Pacific and OMNR across the zone. Site selection and preparation for the jack pine orchard and tests has been completed.

Planning for a tree improvement project for both black spruce and jack pine in a large breeding zone to the east of Lake Nipigon is underway. This breeding zone is fortunate in that a large number of older black spruce selections [intensively selected between 10 & 30 years ago] exist in breeding orchards. These selections will be bred to provide families for testing and seed orchard establishment and will be augmented, if necessary, by new selections. OMNR will proceed with minimal industrial cooperation in this project.

Northern Region

Abitibi-Price Inc., Malette Inc., Quebec and Ontario Paper Co. and the OMNR Districts of Cochrane, Kirkland Lake, and Timmins are cooperating to improve black spruce and jack pine in two breeding zones in the north east portion of the Province. A 16 ha. jack pine seed orchard and three family tests were established in 1987. All are growing well although the white pine weevil and the jack pine shoot borer are causing some damage. A 36 ha. Cochrane breeding zone black spruce orchard was established in 1988 along with four family tests. Droughty orchard site conditions has caused some mortality but mulching with poplar chips should ameliorate the problem. A 16 ha. black spruce seed orchard and three family tests were established in the Timmins breeding zone. All are growing well. OMNR and industry are employing a full time Seed Orchard Manager to coordinate the management of all tests and orchards. Funding for the Manager and the cost incurred in managing these orchards and tests is being shared among the participants based on their forecasted stock requirements.

Supportive Trials

A number of operational studies have been designed and established to support seed orchard management. Fertilizer trials to determine optimum nutrient levels for enhancing both early seedling growth and flower production have been established in both black spruce and jack pine. Crown pruning trials have been established in jack pine to determine the most appropriate regime for controlling height growth without substantially reducing the quantity or quality of cones and seeds produced. Droughty black spruce orchard sites led to the establishment of a mulching trial of poplar chips, straw and pulp mill sludge. All three treatments reduced soil temperature substantially and reduced soil moisture loss however, poplar chips were chosen for operational application as they are readily available at a reasonable cost and are the easiest to handle .

SUMMARY

The Ontario Tree Improvement Council has made significant progress during the first six years of operation. There has been a superb commitment to the program by both provincial government and industrial members as witnessed by the successful establishment of several tree improvement projects and the full time employment of two additional staff to provide technical support. The focus of OTIC members has now changed from establishment to management to ensure that abundant, genetically improved seed is available from the orchards.

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FOREST GENETICS RESEARCH AT THE UNIVERSITY OF TORONTO

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The Faculty of Forestry at the University of Toronto offers undergraduate courses in forest genetics and tree breeding at the second and fourth year level. A graduate course in forest genetics is offered as well.

Research at the Forest Genetics Laboratory (FGL) is coordinated by L. Zsuffa, Professor of Forest Genetics. The laboratory currently has a graduate student complement of three Masters students and three Ph.D. students. During the past two years, two Masters candidates and two Ph.D. candidates defended their theses. Also contributing to studies are two research associates (R.L. Gambles and W.A. Kenney), two research assistants (B. Beatson and B. Vanstone), and a visiting scientist (L. Sennerby-Forsse, Sweden). Another visiting scientist (Zhang Qiwen, China) and a postdoctoral fellow (K.H. Kim, Korea) completed research at the FGL during 1989.

Under the direction of Dr. Louis Zsuffa, research in the FGL includes the genetic improvement, characterization and evolutionary studies of willow, poplar and white pine.

Current research at the FGL, includes: progeny and clonal testing; inter- and intraspecific hybridization; biomass quality studies; assessment of species and clonal variation in nutrient requirements and uptake; resistance to diseases; plant regeneration from callus cultures; isozyme and cp-DNA studies; and linkages and inheritance patterns. Graduate and postdoctoral studies contribute considerably to this research.

This report outlines some of the research being undertaken at the FGL.

SHORT ROTATION INTENSIVE CULTURE (SRIC) AND BIOENERGY RESEARCH

Willows are important in forest genetics research because of their fast growth, wide distribution, richness in genetic diversity (almost untouched natural gene pool), adaptability, and ease of propagation by stem cuttings. The advent of short rotation, intensively managed biomass plantations has resulted in an interest in the potential of willows to supply part of the world's future demand for wood fibre, energy, chemicals, and food. The lack of genetic information on willows impedes progress in an advanced breeding programme.

The FGL has been very active within the International Energy Agency (IEA). The Bioenergy Agreement of the IEA was developed to coordinate an international cooperative research programme aimed at the improvement of biomass growth and production technology in short rotation forestry. Ten cooperative research projects have been completed to date. A new agreement was initiated in 1989, and includes a task entitled Improvement of Energy-Dedicated Biomass Production Systems. Task 5 of the Bioenergy Agreement deals with eight cooperative research projects; production systems, ecophysiology, agricultural/herbaceous crops, pest/disease management, feedstock qualities, tree ideotypes, exchange of genetic material and joint testing of stock. Dr. Zsuffa is the Operating Agent of this Task, and Dr. R. Gambles is the Scientific Secretary. The FGL has led the activity on feedstock quality, has played an active role in all other activities dealing with tree crops, and has maintained close contact with IEA tasks dealing with biomass conversions.

The FGL has also been active with IUFRO working groups on integrated research into biomass, poplar breeding and provenances, and white pine breeding and provenances. Also, we have contributed significantly to the work of the Poplar Council of Canada, and the International Poplar Commission of the FAO.

IMPROVEMENT OF NORTH AMERICAN *SALIX* FOR BIOMASS PRODUCTION BY HYBRIDIZATION AND CLONAL SELECTION

The main objective of this research is to develop superior clonal varieties of North American willow species for woody biomass plantations via hybridization. The species under study are: *Salix amygdaloides* Marsh., *S. exigua* Nutt., *S. discolor* Muhl., *S. eriocephala* Michx., *S. bebbiana* Sarg., *S. lucida* Muhl., *S. pellita* Anderss. and *S. petiolaris* J.E. Smith. Selections have been made over the ranges of these species. In cooperation with the Ontario Ministry of Natural Resources, Forestry Canada, and the State University of New York at Syracuse, we have established and maintained several family and clonal trials.

A series of four clonal screening trials were established in 1987 using material selected from family trials. The family and clonal trials, planted in Maple, Kemptville and Petawawa, Ontario and in Tully, New York, have yielded information on variation in biomass production, growth habit, disease resistance, frost hardiness and the presence of genetic x environmental interaction. In the fall of 1990, these trials were harvested and measured for biomass production. The yields produced by the best of these North American clones surpass those produced by willows in Swedish and United Kingdom programmes (where willows have been cultivated for several hundred years). This information has led to a delineation of clones promising superior biomass yield. These clones are now being propagated for large scale production trials.

Parents with good combining ability were identified in all species under examination. Further breeding work, using the most promising families, has produced material for the establishment of new family trials. Hybridization of good North American clones of *S. eriocephala* with highly productive European clones of *S. viminalis* is on-going and has yielded some promising results. A trial planted at Orono, Ontario in 1990 suggests that some of these European x North American species hybrids exhibit equal or superior growth to their parents and indicate pest resistance not found in the European parents.

TREE-FORM WILLOW

Although research at the FGL has traditionally focused on willow species which exhibit shrub-like growth characteristics, new research has been initiated using tree-form willows. Tree-form willows are fast-growing and promising for a variety of industrial products. They are easily harvested and processed using current industrial technology. Domtar Inc. has demonstrated its interest in this research by offering land and maintenance assistance for tree-form willow trials.

The two major goals of the project are to study tree-form willows by: 1) establishing a demonstration trial (on Domtar Inc. land) of cloned plus trees from a natural stand and trees selected from arboreta (Ontario and European clones); and 2) by studying the maintenance of soil quality through mycorrhizal inoculation of willow.

A demonstration trial was established in the spring of 1991 on Domtar land. A study, entitled "The effect of ectomycorrhizae on the growth and macronutrient uptake of some clones of *Salix alba* and *S. nigra*" was completed in 1991. During 1991, natural willow stands in south and central Ontario will be surveyed in order to select superior trees. Seed will be collected from arboreta and also from international breeding programmes.

QUANTITATIVE GENETIC ASPECTS OF CHEMICAL TRAITS OF NORTH AMERICAN WILLOW

The suitability of biomass as feedstock for energy conversion and/or specialty chemicals will be affected by its cost, availability and quality. While efforts have begun to increase biomass yields through the short rotation intensive culture of poplars and willows, little work has been done to examine the feasibility of improving the chemical quality of such feedstocks.

A study, undertaken by W.A. Kenney as his Ph.D. thesis, assessed the feasibility of genetically manipulating chemical traits which are important to the efficiency of conversion of feedstocks to solid, liquid or gaseous fuels.

The components of variation in biomass chemical characteristics attributable to species, families, and clones within *Salix* were assessed. The broad-sense heritabilities and genotype x environment interaction were quantified for the traits, and phenotypic and genotypic correlations between the traits examined.

The results indicated that improvements to the chemical characteristics of willow may be possible through the selection of species, families and clones. *S. eriocephala* exhibits characteristics favourable to biochemical conversion. It is likely that significant gains can be achieved through manipulation of bark content. The potential to exploit this variation genetically depends upon the heritabilities, genetic correlation among traits, and levels of variation among and within families and clones for such characteristics as number of sprouts, sprout diameter and height, bark thickness, bark and wood specific gravity and pith volume.

DISEASE SURVEYS

Resistance to disease is an important characteristic to observe in any plant breeding programme. In North America, willow breeding for increased biomass production is in its early stages, and it is important to establish the degree of susceptibility, and the variability in that susceptibility, to particular diseases.

Disease surveys, carried out on our field trials, included observations of *Melampsora* leaf rust. Rust can become a serious problem in willow biomass plantations, causing premature leaf fall, reducing growth and weakening the host. This study, undertaken by B. Beatson as her M.Sc. thesis, investigates genetic resistance to disease by establishing the degree of variability in willow species, family and clonal response to attack by the pathogen.

GROWTH RESPONSE OF NORTH AMERICAN WILLOW TO FERTILIZATION

The objective of this study was to compare growth and nutrition of willows raised on inorganic and organic (sewage sludge) fertilizers. This work was carried out by M. Simon as his M.Sc. thesis.

The results of this study show that biomass production was greatly improved through fertilization on nutrient-poor soils. The municipal sludge treatment increased biomass production by an average of 613% compared to the control, while chemical fertilization increased production by an average of 342%. The results indicated that species and clones can be selected which utilize the nutrients in sludge more efficiently and produce a larger amount of biomass.

In a second experiment, three levels of chemical fertilizer were applied in exponentially increasing doses. It was found that species and clones could be selected to remove smaller amounts of nutrients per unit of biomass. The optimum nitrogen addition was found to be 125 kg/ha for most species and clones. Optimal nitrogen addition increased biomass production by 255-484%.

GENETIC CHARACTERIZATION OF *SALIX*

Two Ph.D. students in the FGL are working on the genetic characterization of *Salix*.

Dynamics of isozyme electrophoretic spectra in families of Salix exigua and S. eriocephala and their implementation in willow breeding

This study is being undertaken as a Ph.D. thesis by F.A. Aravanopoulos. The objectives of this research are: to study inheritance and linkage of isozymes in *Salix exigua* and *S. eriocephala*; to investigate tissue differentiation in these species by comparing isozymes of root tips and fresh leaves; and to compare their allozyme heterozygosity with growth parameters and biomass production. In *S. exigua*, variation in parental genotypes exists in 10 enzyme systems, and Mendelian inheritance has been confirmed at 8 loci. In *S. eriocephala*, variation in parental genotypes exists in 7 enzyme systems, and Mendelian inheritance has been verified at 5 loci.

Phylogenetic relationships of willow species based on allozyme variation and chloroplast DNA diversity

This study, being carried out by K. Chong as a Ph.D. thesis, investigates: genetic structure, similarity and diversity of congeneric *Salix* species based on allozyme variation and chloroplast DNA (cpDNA) diversity; phylogenetic relations and evolution of willows using isozymes and cpDNA markers; and the identification of isozymes and cpDNA as genetic markers for the species used.

Promising results are emerging from the chloroplast DNA diversity study. Non-radioactive labelling techniques were developed for the study and are now being used by other laboratories.

INDUCTION AND EVALUATION OF HAPLOID AND DIHAPLOID LINES IN POPLAR SPECIES

The goals of this project were to produce haploid lines of selected willow and poplar species through anther culture and to develop and evaluate haploid and dihaploid clonal lines. Plantlets were obtained in one clone of *Populus maximowiczii*. The majority of these plants were haploid as determined by chromosome counts. Aneuploids and putative dihaploids were also observed. Clonal lines have been established by vegetative propagation of anther-derived plantlets. A Ph.D. thesis, based on this work, was conducted by M.U. Stoehr.

GENETIC CHARACTERIZATION, USING ISOZYMES, OF SOME WHITE PINE SPECIES AND HYBRIDS AND ITS RELATIONSHIP TO BLISTER RUST RESISTANCE

This research was undertaken by E. Chagala as her Ph.D. thesis. The results of this study enables the proper identification of breeding stock, combination of desired traits and certification of controlled crosses. They lead to a better understanding of the genetics of white pine, and may divulge information on the genetic control of blister rust resistance and other important silvicultural traits.

The genetic structure, linkage relationships and genetic variation of *P. strobus, P. griffithii, P. monticola, P. peuce* and *P. koraiensis* were investigated by isozyme analysis using starch gel electrophoresis. Methods for using isozyme analysis for the identification of these species and interspecific hybrids were also investigated.

Most enzyme systems analyzed were shown to be under multiple gene control. Thirty-six loci coded for the 13 enzyme systems in each of the species. Determination of linkage relationships among the 36 gene loci revealed up to three linkage blocks in each species. Further observations indicated that most of the linked genes were on the same chromosome. Substantial genetic variation was evident in all the species. The mean values of average heterozygosity, proportion of polymorphic loci, and number of alleles per locus were calculated and found to be comparable to those of other conifer species. Genetic similarities and distances, and divergence times, based on allele frequencies, were calculated. These results, along with results from a cluster analysis, showed that *P. strobus, P. monticola* and *P. griffithii* were genetically the closest species while *P. peuce* and *P. koraiensis* each formed separate clusters. Several alleles were identified as markers for all of these species and their interspecific hybrids.

PROVENANCE VARIATION IN *PINUS STROBUS* L.

This research was initiated in order to define genetic and environmental components of phenotypic variation associated with geographic sources; patterns of genetic variation; juvenile/mature correlations; and provenance-environment interaction. Provenance variation in eastern white pine was investigated on the basis of 12 range-wide geographic sources. Thirteen growth and morphological characteristics of the provenances were measured and scored. Statistical analysis consisting of univariate, multivariate and non-parametric methods was used for these data.

Results showed that eastern white pine is highly variable and displays well-defined patterns of variation. An east-to-west clustering of provenances was found, possibly caused by adaptation of the species to moisture distribution (there is significant correlation between longitude and rainfall). In addition to environmental effects, variation was discovered as the consequence of restricted gene flow, genetic drift and natural selection. Juvenile-mature correlations for ages above 7 years were high, thus evaluations at age 7 or higher would be useful in selecting the best provenances. A M.Sc. thesis, based on this research, was completed by H. Ibrahim.

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MANITOBA'S TREE IMPROVEMENT PROGRAM, PROGRESS REPORT

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Keywords: jack pine, black spruce, white spruce, seed orchard, co-operative

The provincial tree improvement strategy was published in 1991. Tree improvement programs have now been established for the primary species in the most active breeding zones of Manitoba. The jack pine (*Pinus banksiana* Lamb.) improvement program was initiated in 1967 by Forestry Canada. Black spruce (*Picea mariana* (Mill.)B.S.P.) and white spruce (*Picea glauca* (Moench) Voss) programs have been established by the Manitoba Forestry Branch (M.F.B.) and through the Manitoba Tree Improvement Co-operative with Abitibi-Price Inc., Repap Manitoba Inc. and M.F.B. This report highlights the progress which has occurred from the summer of 1989 to 1991.

JACK PINE

The 15-year measurements of the Eastern Breeding District family test were analyzed in 1990. Due to changes in family rankings, from the 10-year measurements, and the need to expand the pedigreed seed orchard to 10.0 hectares, additional crosses were conducted within the family test in 1990 and 1991. Seed from these crosses is also being used by Forestry Canada in a Western gall rust (*Endocronartium harknessii*) resistance study. The 20-year measurements of the family test will be completed in the fall of 1991 and used to identify the single-pair matings to establish the second generation improvement program.

Survival and growth of the mass selection seed orchards established in the Northern (1986) and Interlake (1987) Regions of Manitoba has been exceptional. The first roguing of the Northern Region orchard will occur in the fall of 1991 with 50% of the trees removed based on their performance on the orchard site.

BLACK SPRUCE

A lack of precipitation in Southern Manitoba during the period of July 1989 to January 1990 resulted in severe desiccation damage to the Southeast Breeding Zone family test plantations. Survival dropped from 98% after two years to 68%. To offset the damage, replications were refilled from on-site spares and ten new replications will be established in 1992. The need for strict vegetation control in family tests is now balanced against the benefits of initial shading during early establishment, particularly in the southern half of Manitoba.

The 7.5 hectare black spruce seedling seed orchard for the Abitibi-Price: M.F.B. co-operative program was planted in 1990. Survival rates for the orchard and three family test plantations remain above 90%. In addition, dead trees are refilled for the first two years from spares planted on site.

Two - 2 hectare mass selection seed orchards have been established in the Interlake Region of Manitoba in the spring of 1991. This lower cost improvement program has a single tree from each of 400 families planted in a replication, with 32 replications per site. Each replication is divided into 4 blocks which are planted at a 1 metre X 1 metre initial spacing and surrounded by a 3 metre access corridor. Every 4-6 years 50% of the trees are rogued based on their performance on the orchard site.

Three black spruce family test plantations were established in 1990 as a part of the Repap: M.F.B. co-operative program. A fourth site has been planted in 1991 to offset initial losses on two of the original sites, resulting from inappropriate site preparation and stressed planting stock. A 7.5 hectare seedling seed orchard was also planted in 1991 completing the establishment phase of the co-operative program for the Saskatchewan River Breeding Zone.

WHITE SPRUCE

An open-pollinated progeny test was established on four sites in the Mountain Breeding Zone in the fall of 1989. There are 15 replications per site using single tree plots from each of 336 families. Each site is fenced to prevent browsing damage. Scions from the plus trees have been grafted with the aim of establishing a 4.5 hectare clonal orchard in 1993.

SUMMARY

The first phase of the provincial tree improvement strategy has been established. The second phase involves establishing co-operative programs for the second priority species and breeding zones, as well as supportive research. The supportive research is expected to be completed by Forestry Canada through the Canada- Manitoba Partnership Agreement in Forestry. However, implementation of the second priority improvement programs is expected to be delayed until new co-operative programs are approved.

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TREE IMPROVEMENT IN SASKATCHEWAN'S BOREAL FOREST

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Keywords: Jack pine, white spruce, aspen, pilodyn, 10 year selections

After 12 years of jack pine (*Pinus banksiana* Lamb.) tree improvement operational seed requirements are being met, a phase of breeding work has been completed, and initial 10 year results indicate a 7.5% volume gain and significant genotype/environment interaction. After 8 years of white spruce (*Picea glauca* (Moench) Voss) tree improvement most operational seed needs are being met and progeny tests of 1st generation selections are still being established. A low key aspen program is being evaluated.

JACK PINE PROGRAM

Operational injections of $GA_{4/7}$ in an 8 ha clonal orchard are being used to boost cone production, and the 1992 orchard harvest should meet all operational seed needs. In the meantime seeds are collected from both selected stands and trees to supplement orchard production.

A set of tests to evaluate the performance of clones in the orchard over the sites found in our operating area was started in 1991.

A breeding program among orchard clones was completed in 1991, and the first full-sib seedlings resulting from that work have been outplanted.

The oldest of a series of progeny tests of 200 other selections were measured at 10 years. On a **family** basis the correlation between 5 and 10 year volume was strong ($r^2=.88$), but the selected **individuals** within those families changed greatly. Volume gain of select verses non-select trees was 7.5%. There was a significant family genotype/environment interaction shown over the sites tested on. An average of 2 pilodyn readings correlated well with the relative density of wood discs taken at the same height on an individual tree basis ($r^2=.735$), and relative density was taken into consideration when making 10 year selections. Ten year selections have been grafted, and breeding among them to get 3rd generation seed to test will begin as soon as the grafts are large enough.

WHITE SPRUCE PROGRAM

Early cone production in a 7.2 ha clonal orchard is supplemented by collections from an established seed production area and select trees, so that most operational seed needs are being met through the tree improvement program.

Three sets of progeny tests from over 200 other selections have been established, and a 4th set of tests will be established as soon as the required cones are produced on the select trees.

ASPEN

A low level of participation in aspen tree improvement has been ongoing for 3 years, and is being evaluated in light of foreseeable silvicultural practices.

SHELTERBELT TREE IMPROVEMENT PFRA SHELTERBELT CENTRE

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Keywords: shelterbelt, windbreak, progeny test, seed orchard, provenance test.

The primary objectives of the tree improvement program at the PFRA Shelterbelt Centre is to develop genetically superior tree and shrub species for shelterbelt planting in the prairie provinces of western Canada. From 1989 to 1991 this program has focused on *Pinus sylvestris, Larix sibirica, Fraxinus pennsylvanica, Quercus macrocarpa* and *Celtis occidentalis*.

PINUS SYLVESTRIS

Two full-sib, and three half-sib progeny tests as well as a clonal seed orchard were established in 1990. The seed orchard includes twenty clones arranged in a systematic design. In 1991 a half-sib progeny test of ten families from seed collections in the USSR was planted.

LARIX SIBIRICA

Five year assessment of a Siberian larch provenance test was completed in 1989. Mean height of the planting was 214 cm. The best source originated from Ivanovskaya oblast (Lat. 57.00°N, Long. 42.30°E). Height of this source exceeded the plantation mean by 18 percent. Range wide provenance tests were established at four sites in Manitoba, Saskatchewan and Alberta in 1991.

FRAXINUS PENNSYLVANICA

Provenance testing of green ash is underway at six locations in the prairie provinces. Detailed studies are underway investigating water relations of green ash. The objective is to investigate genetic variation in seasonal stomatal conductance, leaf water potential and dehydration tolerance of five green ash populations.

CELTIS OCCIDENTALIS

A provenance test which sampled the native range of hackberry in the northern Great Plains of North America was established in southern Manitoba. The objectives of the test are to: (1) identify the extent and patterns of genetic variability in hackberry; and (2) identify the seed sources of hackberry best adapted for planting in southern Manitoba.

QUERCUS MACROCARPA

A provenance test which samples the native range of bur oak in the North American Great Plains is being co-ordinated by the Shelterbelt Centre. The co-operative study will include two provinces and eight states. Objectives of the test are: (1) to determine the nature and extent of genetic variation present among open-pollinated progenies of bur oak from selected sources in the Great Plains; (2) to identify best adapted sources of bur oak for planting in the Great Plains; and (3) to provide germplasm that can be used for selection and trait improvement as well as advanced generation breeding. Seed collection areas have been identified and collection will be initiated in fall 1991.

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GENETICS AND TREE IMPROVEMENT ACTIVITIES AT THE UNIVERSITY OF ALBERTA

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Keywords: Inheritance, mating system, population structure, species hybridization, systematics, isozymes, molecular genetics, mycorrhizae, quantitative genetics, tree improvement

MATING SYSTEM, POPULATION STRUCTURE, SPECIATION, AND SYSTEMATICS

Isozyme Genetics: Agnes Vanede completed her Ph.D studies, "Analysis of Gene Flow in Populus Species Using Flavonoids and Isoenzyme Markers", under the joint supervision of Bruce Dancik and Keith Denford (Botany). Hong Zhu completed his Ph.D studies, "Extracellular Acid Proteinase of an Ectomycorrhizal Fungus *Hebeloma crustuliniforme*: Characterization, Regulation and Function", under the joint supervision of Bruce Dancik and Ken Higginbotham. PDF Yang Rong-Cai and Francis Yeh developed the algorithm that considered repulsion and coupling phase gametic disequilibrium to analyze multilocus association in natural populations. Yang Rong-Cai is also studing mating system and multilocus population structure in *Cunninghamia lanceolata*.

Molecular Genetics: Graydon Smith is continuing his M.Sc studies of phylogenetic relationships in the *Pinus contorta* Dougl. complex using chloroplast DNA. John Barrett under the joint supervision of Bruce Dancik and Curtis Strobeck is continuing his Ph.D studies on the organization and structure of light-harvesting chlorophyll a/b binding genes in *P. contorta* Dougl. complex. PDF Om Rajora completed his studies on inheritance and variation of mitochondria and chloroplast DNA in *Populus*. PDF Jane Sampson completed introgression studies of *Picea glauca* (Moench) Voss with *P. engelmannii* Parry using chloroplast DNA. Research Associate Ken Egger continued studies on population variation of rDNA intergenic spacer length in *Populus tremuloides*. Technologist Mary Aleksiuk, Dancik, and Yeh completed a systemtic study in conifers using non-radioactive labelled chloroplast DNA. Chloroplast DNA studies of *P. contorta* Dougl. and *P. banksiana* Lamb. with Dave Wagner, University of Kentucky, continue.

Funds for these studies have been provided by NSERC operating and Forestry PDF grants, and Forestry Canada.

TREE IMPROVEMENT

Very Early Evaluation: Bruce Dancik, Richard Pharis (Calgary), Francis Yeh, and PDF Israel Jiang completed studies of very early (90-180 day) genetic evaluation of several *Pinus* spp. Ph.D student Wu Xiaming completed the experimental phase of his early genetic evaluation in *Pinus contorta* spp. *latifolia* (120 open-pollinated families). He is continuing with the statistical analyses and interpretation.

Breeding: Wu Xiaming is developing theoretical components for early selection in *Pinus contorta* spp. *latifolia*. Israel Jiang and Francis Yeh completed a study of genotype-environment interaction useful for advanced-generation breeding of *Pseudotsuga menziesii* (Mirb.) Franco. Luiz Kulchetscki under the joint supervision of Francis Yeh, Vic Lieffers, and Trevor Thorpe (Calgary) is continuing his Ph.D studies of micro-propagation in *Abies amabilis* (Dougl.).

Tree Improvement Specialist Sally John is continuing a collaborative project with forest industries in *Populus tremuloides* and is continuing studies of phenology and pollen dynamics to monitor how much outside pollen enters the Alberta Tree Improvement Cooperative seed orchard at Huallen.

Funds for these studies have been provided by NSERC strategic grant, Alberta Forest Development Research Trust, and Alberta Forest Products Association and Alberta Forest Service under the NSERC University-Industry Program.

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TREE IMPROVEMENT IN THE NORTHWEST REGION

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Keywords: Jack pine, family test, multiple-trait combined selection, seed orchard

Analysis of 15-year jack pine family test data, multiple-trait combined selection, and pair mating of selected family test trees to produce seed orchard progenies have been the main focus of the program for the past two years.

Measurement data to 15 years from planting have been analyzed for the eastern breeding district (EBD), in southeastern Manitoba, and the western breeding district (WBD), in central and western Saskatchewan. In addition to height and diameter, data were analyzed for stem quality, infection by western gall rust (gall counts provided by Dr. Y. Hiratsuka), and wood density estimated from Pilodyn determinations. Gall counts were transformed to proportionate ranks prior to analysis, to reduce the departure from normality. Heritability of family means, of mass selection of individual trees, and of within-family selection, were calculated for height, diameter, stem quality, and rust gall rank. Only family heritability was calculated for wood density.

A scoring system was developed and applied to the trees in the two family tests. Family means and individual values for the various traits were expressed as deviations from a mean divided by a standard deviation. Each such standardized effect was multiplied by the applicable heritability to produce a score component. Fractional weights were applied subjectively to achieve appropriate proportions of trait contributions to total score. Score records for trees with promising scores were sorted and ranked, excess records deleted, and a list of 48 selected trees produced. Only one tree was selected in any family, but back-up trees in the same families were also listed, for use when a selected tree was found to be dead, damaged, or not really as good as described.

Different versions of the scoring system were applied to select seed orchard parents in the western (1990) and central (1991) Saskatchewan plantations of the WBD family test, and in the EBD plantations in 1991. For the EBD, more gain was available from a combined select list from two neighboring southerly locations (Lones and and Marchand) than from the northern (Stead) plantation select list. Selected trees were paired assortatively in 1990 and for the EBD. For the 1991 WBD mating, the 1990 pairing was used for trees of families selected both times.

The two years' crosses in Saskatchewan should yield sufficient seed from an adequate number of unrelated parent pairs for planting a pedigreed seedling seed orchard in 1992. Related progenies will be treated as though they were ramets of the same clone. Another year of mating may be needed to provide seed from enough matings to plant the last 4 ha of eastern breeding district seed orchard. The first 6 ha were planted in 1988 with progenies of family test trees selected on 10-year performance. Genetic gain was 11-14% for volume at 15

years, 7-9% for stem quality rating (on a 1-5 scale) and 6-32% for rust gall rank, depending upon the level of infection. Wood density was virtually unchanged.

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GENETICS AND TREE IMPROVEMENT PROGRAMME ALBERTA FOREST SERVICE

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Keywords: Tree breeding, genetic improvement, provenance studies, species testing, seed orchards, progeny testing, white spruce, lodgepole pine, aspen.

This report summarizes the progress of the Alberta Forest Service (A.F.S.) genetics and tree improvement programme for the period 1989-1991.

PROGRAMME DEVELOPMENT

A comprehensive review of breeding regions delineated in the late 70's was carried out in order to update technical planning and to accommodate new Forest industry in the cooperative tree improvement program. The program was finalized into ten breeding regions which were designated to various genetic improvement projects in the following manner: five for white spruce (*Picea glauca*), four for lodgepole pine (*Pinus contorta* var. *latifolia*) and one for Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) . In addition, two more breeding regions were identified for possible future projects. Discussions are continuing with concerned new industry (ANC Timber Ltd., Alberta Pacific Forest Industries Inc., Daishowa Canada Co., Millar Western Industries Ltd., and Weyerhaeueser Canada Ltd.) to finalize cooperative cost and work sharing arrangements for various projects.

Due to rapid forest industry development in Alberta and enhanced forest regeneration standards implemented earlier this year, provincial nursery production needs are expected to increase from 30 million seedlings to 103 million seedlings annually by 1995. In view of this, tree improvement program emphasis was shifted from establishing additional new seed orchards to expansion of existing seed orchards in order to meet revised seed production requirements. A new project was established for selection and breeding of trembling aspen (*Populus tremuloides*) and poplar hardwoods. The work will focus on specific regions of Alberta with more emphasis on aspen.

GENETIC IMPROVEMENT

Assembly of Breeding Stock

Field selection of superior trees to provide base material for Alberta Forest Service (A.F.S.) as well as A.F.S./Industry cooperative genetic improvement projects continued. As part of A.F.S. responsibility projects, a total of 70 trees were selected in Douglas-fir , lodgepole pine , black spruce (*Picea mariana*), western larch (*Larix occidentalis*), white spruce, and tamarack (*Larix laricina*). As part of the A.F.S./Industry cooperative projects, a total of 55 white spruce and 25 lodgepole pine trees were selected jointly with Blue Ridge Lumber, Canadian Forest Products, and Weldwood Canada.

Superior tree selections are invariably evaluated for wood density and fibre length. Results of wood quality evaluations carried out during the 1989-91 period are summarized in Table 1.

Table 1. Summary of Wood Density and Fibre Length by Species for Period 1989-91.

SPECIES	NUMBER OF TREES TESTED	DENSITY Mean ± SE (Range)	FIBRE LENGTH (mm) Mean ± SE (Range)
White Spruce	52	0.328 ± 0.003 (0.280 - 0.374)	3.09 ± 0.01 (2.70 - 3.57)
Lodgepole Pine	44	0.408 ± 0.004 (0.360 - 0.467)	2.66 ± 0.04 (2.17 - 3.06)
Douglas-fir	14	0.423 ± 0.007 (0.381 - 0.480)	2.76 ± 0.08 (2.09 - 3.18)
Black Spruce	3	0.375 ± 0.011 (0.356 - 0.402)	2.63 ± 0.25 (2.03 - 3.04)
Trembling Aspen	29	0.380 ± 0.003 (0.345 - 0.412)	N/A

Genetic Testing

As part of lodgepole pine genetic improvement for breeding region "B2", two open-pollinated half-sib family field trials were established jointly with Procter and Gamble Cellulose in spring 1990. The trials contained 453 - 455 families. Experimental design is sets in reps randomized complete blocks using single tree plots.

Field measurements and data analysis were carried out on two sets of lodgepole pine half-sib family field trials. Each set contains four test sites corresponding to breeding regions "B1" and "C" which were outplanted in 1981 and 1982 respectively. The results from "B1" trials will be used to carry out a first rogueing in the seedling seed orchard established by Canadian Forest Products and Procter and Gamble near Grande Prairie. Region "C" trial results will be used to cull about half of the poorest performing seedlots. The remaining seedlots will be used to produce planting stock for a seed orchard to be established by Blue Ridge Lumber in 1993.

Seed Orchards

Fill-in planting of grafts continued for regions "E", "G" and "H" seed orchards which were started in 1988-1989. Stock production has commenced for a region "D" white spruce seed orchard to be established by Blue Ridge Lumber in 1993. Douglas-fir and western larch seed orchards established in 1989 suffered severe winter damage and mortality. These orchards were established as part of the Jumping Pound Demonstration Forest in Kananaskis Country. Upon review, it was decided to drop the production seed orchard from the Demonstration Forest concept and re-establish them at a climatically and edaphically more suitable location. For this, a new site was chosen at Brooks in southeastern Alberta and new grafting to produce orchard planting stock is in progress.

Detailed site evaluations were carried out on several land parcels in order to find suitable sites for two regional seed orchard developments. One land parcel near

Whitecourt was selected for the cooperative seed orchard to be developed by Blue Ridge Lumber. A soil survey of the site was completed and site development is in progress.

Flowering and cone production monitoring continued on one lodgepole pine and four white spruce seed orchards. A stratified randomized sampling design with six percent intensity is being used at present. Flowering and cone production during 1990-1991 were very light.

GENETICS AND TREE IMPROVEMENT RESEARCH

Species Testing

As part of the Alberta tree improvement program, species testing has been in progress for nearly 13 years. Results so far have provided several promising leads which will be pursued with more detailed testing. It was decided that further work on exotics will concentrate on Siberian larch (*Larix sibirica*), Scots pine (*Pinus sylvestris*) and red pine (*Pinus resinosa*).

The native species testing program is primarily focusing on interior Douglas-fir to probe the possibility of extending its planting range northward to central Alberta.

Three Scots pine field trials were established with selected seed origins from the U.S.S.R. The seedlots in these trials correspond primarily to geographic origins that performed well in earlier Alberta field trials. Individual open-pollinated single tree seedlot identity was maintained in these trials to provide the opportunity for selection and breeding. Three additional Scots pine trials were established with seedlots from Sweden and Poland. Many of these seedlots are from seed orchard seed collections. All trials contain local lodgepole pine or jack pine as 'check' seedlots.

Red pine testing was narrowed to three seed sources from north western Ontario and northern Minnesota. A nursery trial was established in 1990 to screen out less winter hardy trees prior to field outplanting.

Triploid hybrid aspen trials were established at four sites in northern Alberta. Planting stock for these trials was obtained from Blandin Paper Company in Minnesota. The northern most trial was located near Peace River and was established cooperatively with Daishowa Canada.

Douglas-fir seedlings grown with seed collected from more northern stands in Alberta was established at Pine Ridge Nursery in central Alberta for winter hardiness screening.

Provenance Studies

Twelve year assessment of a Canada range-wide white spruce provenance trials established in central Alberta was completed. Results showed that the top ten fastest growing provenances originated from southern Manitoba, Ontario, or Quebec. These were significantly taller than the best local provenance in the test. Best height growth was shown by a southeastern Manitoba seed source which was 20% taller than the best local provenance. There were no significant differences in survival among provenances. In light of these interesting findings, white spruce provenance testing with promising non-local seed sources was expanded. A new series of provenance trials were planned and nursery sowing is completed for the first set of trials to be field planted in 1993. In addition, several operational white spruce seedlots were obtained from southeastern Manitoba. These were sown in the nursery to produce planting stock for large block plantings to be established on a number of operational reforestation sites in 1992.

Field measurements and data analysis continued on a series of white spruce provenance trials established across the province from an Alberta-wide collection made during 1980-83. A research contract was established with Dr. E.K. Morgenstern of the University of New Brunswick to review provenance work in Alberta and to assist with developing seed zones and new seed movement guidelines for operational reforestation in the province.

Field outplantings were done for four black spruce, 5 Douglas-fir and three lodgepole-jack pine (*Pinus banksiana*) provenance trials. These trials contain a collection varying from 8 to 36 Alberta wide seedlots.

Seed Production and Wood Quality Studies

A study was carried out to assess suitability of the pilodyn in evaluating wood density of trembling aspen ortets prior to field selection. A total of 29 mature aspen trees spread over 25 square kilometres in central Alberta were sampled. The trees ranged in age from 36 to 79 with an average of 57 years. Pilodyn pin penetration measurements were taken from individual trees with a 12 joule unit. Wood discs were also collected from the same trees at dbh for lab evaluation of wood density. The results showed a strong relationship ($r = 0.87$) between pilodyn pin penetration readings and relative wood density. The predictive regression equation was $Y = 0.5615 - 0.0063X$, where Y = relative density and X = pilodyn pin penetration in mm. The R^2 value for the model was 0.76.

An earlier experiment on supplemental pollination of lodgepole pine in a research seedling seed orchard was repeated. The results showed that supplemental pollination increased the average number of seeds per cone by 56 percent over wind pollination alone. These results were consistent with results from the first experiment which showed 44 percent increase in number of seeds per cone due to supplemental pollination. However, in both experiments, seed produced by wind pollination alone was slightly (7 percent) heavier than supplemental pollinated seed.

Due to space required for construction to expand the greenhouse complex at Pine Ridge Forest Nursery, a large part of the research seed orchards and several other seed production research trials had to be moved to a new area. This was done in September, 1990 with large tree spades. All trees survived the move and a new study was set up to monitor any effect transplanting may have on flowering and seed production.

RARE AND EXCEPTIONAL STANDS

A pilot Rare and Exceptional stand project to identify stands exhibiting exceptional phenotypic traits or rare characteristics was initiated in 1986 in Slave Lake Forest as a C.A.F.R.D.A. project. The purpose was to develop a methodology that could be expanded to other Forests and used to designate rare and exceptional stands to be protected as gene pool reserves for long term conservation. Under this program five exceptional white spruce stands, one rare black spruce and one rare tamarack stand were identified and reserved in Slave Lake Forest.

Since this initial project, the program has been conducted on a less ambitious scale with the designation of three exceptional and one rare Douglas-fir stands for the period 1988-1991.

The intent is to try and streamline the stand survey process and integrate the project as part of operational superior stand identification projects within Forests.

PLANT PROPAGATION AND SEED TECHNOLOGY

During the report period stock production consisted of 74,022 seedlings, 4907 grafts, 6560 potted rootstock trees, and 160 stecklings. The grafting program consisted mainly of white spruce and lodgepole pine with a total of 2521 grafts and 1560 grafts respectively being completed over the report period. A 65% success rate was achieved with white spruce, and a 90% success rate with lodgepole pine. Other species grafted were Douglas-fir, western and Siberian larch, black spruce and Scots pine.

A total of 382 seedlots were added to the genetics seed bank. A large percentage of these seedlots were deciduous (aspen, balsam poplar (*Populus balsamifera*) and plains cottonwood (*Populus deltoides* var. *occidentalis*). The seedbank presently contains 3349 seedlots.

Quality of seedbank seedlots continues to be monitored annually by testing a set of reference seedlots representing about 2% of seedbank entries. White spruce mean germination has declined from 91% in 1981 to 86% in 1991; lodgepole pine mean germination has declined from 87% in 1981 to 80% in 1991. New seedlots are added to the testing program every five years to replace depleted seedlots and to keep the sampling level at about 2% of total seedbank entries. Trembling aspen and white birch (*Betula papyrifera*) seedlots were also added this year to reflect their growing importance in the seedbank.

The ultra-low temperature seed storage study, started cooperatively with the National Tree Seed Centre at Petawawa, is now in its third year. Average germination for white spruce after 3 years at - 80° C is 80% compared to a "baseline" average germination of 82%. For lodgepole pine, average germination is 82% compared to an average "baseline" germination of 84% However, after an artificial aging treatment, average germination of white spruce was reduced to 42% and that of lodgepole pine to 19%. Notably, lodgepole pine germination was better for the non-stratified control (41%). The study will be continued for one more year although from results to date it is evident that -80° C storage temperature does not offer any advantage over conventional -20° C storage and may in fact be detrimental to white spruce and lodgepole pine.

Another cooperative research study was carried out with the National Tree Seed Centre on the effects of cone scorching on germinability, vigour and seed extraction efficiency of lodgepole pine seeds in Alberta. Results indicated that a 1.5 minute scorching treatment at 220° C was the most desirable relative to other treatments. High extraction efficiency and high overall germinability were shown. It was also found that kilns which do not allow for immediate removal of released seeds from the high temperature environment (such as the kilns at the Genetics and Tree Improvement Centre in Alberta and at Petawawa National Forestry Institute) cause significantly lower seed vigour in comparison to kilns which allow released seeds to drop out of the kiln immediately. In view of these results, modifications of our extraction system are being considered.

GENETIC IMPROVEMENT OF COASTAL DOUGLAS-FIR IN BRITISH COLUMBIA

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Keywords: Douglas-fir, breeding, advanced generation, inbreeding, harvest index, selection, age-age correlations

FIRST GENERATION BREEDING PROGRAM

The primary test group of the first generation Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) breeding program consists of 372 parents mated in 62 six-tree modified half-diallels and tested across 11 sites per series, for a total of 88 sites established between 1975 and 1985. Selections are 75% complete for an advanced generation seed orchard which is currently being established near Bowser on Vancouver Island. A selection index approach using volume and pilodyn wood density, followed by field assessments of form on a selected group, is being used.

Maintenance and periodic assessment of other tests continues. These include wide crosses (28 sites), factorial (2 sites), open-pollinated tests (10 sites), polycross tests (2 sites) as well as a material such as inbreds and provenance collections. This material will continue to provide information to guide the program, be used for associated research projects and, in combination with the diallel program, generate material for advanced generation breeding.

ADVANCED GENERATION BREEDING PROGRAM

To date, most advanced generation selections are from the diallel program, and are based on a selection index procedure using 12-year volume and pilodyn wood density. Stem, branch and top form traits are assessed on a select group prior to making the final breeding population selections.

The advanced generation program will incorporate a complimentary mating design, with polycross tests to estimate parental GCA values and family blocks for selection forward to the next generation. Sublines are being used to control coancestry. A potted breeding arboretum and cone induction techniques will be used to shorten the breeding phase.

SUPPORT RESEARCH

In addition to the main breeding program, a support research program continues. Projects include early selection, age-age correlations (cooperation with S. Magnussen, Forestry Canada), wood quality assessment, harvest index and propagation/rootstock incompatibility. Superior clones in the clonebanks are also being mated on a large scale for operational seed production.

GENETIC RESISTANCE TO THE WHITE PINE WEEVIL IN SITKA SPRUCE

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Completion of the seed transfer guidelines for both the coastal and interior species (British Columbia Ministry of Forests 1989/90) represents one of the major contributions from the provenance research program. Silviculture staff need these guidelines to ensure the use of adapted and productive seed sources in reforestation.

We have identified provenances highly resistant to the white pine weevil (*Pissodes strobi*) from Haney, near Malcolm Knapp Research Forest of University of British Columbia, Big Qualicum of eastern Vancouver Island, and also those from the Sitka-white spruce hybridication zone. Trees from Haney and Big Qualicum are also fast growing. Provenance differences in weevil resistance have been verified in a clonal trial suggesting a strong genetic component (Ying 1991). Use of source materials resistant to the white pine weevil, the most damaging pest to Sitka spruce plantations, may help renew the planting of this magnificent and valuable timber species in the coastal region of British Columbia.

Six year results of a range-wide provenance testing of noble fir (*Abies procera*) showed no discernable pattern of geographic variation. But a north-south latitudinal and low-high elevational pattern was evident in ten year results of a grand fir (*Abies grandis*) provenance testing; north and low elevation provenances grew faster and less susceptible to the needle disease (*Uredinopsis longimucronata*).

Opportunity arose last year for genetic research in hardwood species which saw the initiation of the red alder (*Alnus rubra*) provenance study.

Emphasis on provenance research will gradually shift to hardwood and other 'minor' species, and problem-solving research. But we will continue to monitor the long-term provenance tests which is extremely important to the uncertain future about climate change.

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GENETIC IMPROVEMENT OF YELLOW-CEDAR
GENETIC RESEARCH IN RED CEDAR

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YELLOW-CEDAR

A tree improvement strategy involving clonal forestry has been developed for yellow-cedar (*Chamaecyparis nootkatensis*). Genetic tests, using offspring from parent trees mated in 8-clone disconnected, partial, circular diallels, will be clonally replicated and will serve the dual purpose of providing selections for an advanced generation breeding population and information for selection of improved clones for production. Parent trees were selected in the late 1970's and are currently represented in two seed orchards and a breeding orchard. Six diallels were completed in 1991 (out of a total of 24 proposed) and the first genetic test will be planted in 1994/95. Two years of physiological and morphological data from the yellow-cedar short-term genetic architecture and adaptability study has been collected and preliminary seed transfer guidelines should be developed by early 1992. Seed has been sown for six long-term provenance field tests to be planted in 1991/92.

RED CEDAR

Past research has indicated that redcedar (*Thuja plicata*) has minimal isozyme variability (Yeh 1988), a low outcrossing rate in seed orchards (El Kassaby unpubl. data), and no inbreeding depression in seed traits (Owens et al 1990). Studies have been initiated to address the above findings using a larger genetic base and measuring seedling growth and adaptability. Field trials have been established with 100 open-pollinated families from a clonal seed orchard. These trials will be periodically measured for growth, form, and survival. Forty of the above clones were both selfed and mated with a 10-clone polymix. Seed has been collected and sown for an adaptability study (growth rhythms, frost hardiness, water relations) and field trials (growth and survival). It is anticipated that early information from both trials, as well as that from supporting research, will determine if genetic improvement is feasible, and if so, the appropriate strategy.

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WESTERN HEMLOCK TREE IMPROVEMENT EFFORTS

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PACIFIC NORTHWEST COOP FOR WESTERN HEMLOCK IMPROVEMENT

Commercial activity for western hemlock is concentrated mainly in coastal areas of the Pacific Northwest where natural regeneration is often prolific. In order to make a plantation hemlock program worthwhile, genetic gain will have to be pursued aggressively but economically. This can be accomplished by capitalizing on extensive past investments in western hemlock progeny testing. Because this past investment is spread throughout Oregon, Washington and British Columbia it is proposed that a western hemlock tree improvement coop (HEMTIC) is formed under the umbrella of the Northwest Tree Improvement Cooperative (NWTIC). Major initiators in this effort have been John King (BCMoF, Victoria BC) and Jess Daniels (DNA, Centralia WA) and members will include most of the major industry and government agencies in the Pacific Northwest. This coop has a genetic resource comprising over 2000 progeny tested families from northern Oregon to Northern Vancouver Island which are from one to twenty years of age.

An advanced generation program for western hemlock is currently being initiated and incorporates two phases: the first is the use of this current extensive progeny testing for a broad based family screening, and the second is the use of this first phase to construct an advanced phase breeding population for recurrent selection. These two phases are not necessarily sequential; advanced phase selections and crossings are currently being made at the same time as new first phase parents are being established for screening in progeny tests. Until more information is available on juvenile mature correlations, the work of the breeding program is spread out over a breeding cycle generation of 15 years.

One of the important initial considerations in planning the development of this advanced generation breeding program for western hemlock has included investigations of natural genetic variation and the determination of regional boundaries to ensure the breeding population is based on genotypes adapted to local growing conditions.

GEOGRAPHIC VARIATION

An investigation of most available information on geographic variation patterns for western hemlock has been made (King 1990). Of available information investigated, including the three open pollinated (OP) progeny test series of the BC Ministry of Forestry (BCMoF), and published material from Oregon and Washington (Foster and Lester 1983), only one of these series of experiments showed significant site x family interaction indicating genotype x environment interaction (GEI). Significant GEI was present in the first series OP test (BCMoF) and this was due to strong elevational contrasts between sites (150-1100m) (King 1990). Significant and strong positive family mean correlations existed between the low elevation sites in this series (<600m) as well as between high elevation sites (>600m). But there were non-significant ($P<.05$) or significant negative family mean correlations between high and low elevation sites. Conclusions reached were that altitude above 600m might be a deciding factor for breeding zone delineation but latitude in the broadly defined region of South Coastal BC is not a factor.

The other information that has helped in decision making in regards to defining breeding zones is research by Kuser and Ching (1980, 1981). This was a common garden experiment of seedling growth and frost tolerance from a wide range of provenance sources. In summarizing the data presented, no trends were observed for a broadly based region defined as low elevation (<600 m) from North Vancouver Island (51°) to the Columbia River (46°) (King 1990). This is the area where most commercial interest for intensive silviculture (includes planting) with western hemlock is centred and where most of the past selections and progeny testing has occurred.

Although this preliminary investigation would indicate breeding regions can be defined large, the advanced generation plan is to structure the advanced phase program into local population 'sublines' but have also have the 'elite' or top parents from each subline in an overcrossing structure. Evidence from demonstration trials incorporating selected material and unselected provenance material should help in defining regions for future rounds of breeding.

CURRENT ACTIVITIES

- 60 advanced generation selections per year based on height and volume from current tests.
- Measurements for wood density and pulping components from the first series of hemlock OP tests.
- Advanced phase crossing on re-selected parents. The first series of diallel crosses is about 2/3 complete.
- Establishment of 90 polycrossed first phase families
- Sowing of more polycross families and re-selected full-sib crosses for testing and genetic gain demonstration.

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GENETIC IMPROVEMENT OF WHITE AND ENGELMANN SPRUCE

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The objective of this project is to produce genetically improved planting stock of white and Engelmann spruce (*Picea glauca* (Moench) Voss and *Picea engelmannii* Parry).

PROGENY TRIALS

Six-year height measurements of 550 interior spruce progenies were completed and evaluated (Kiss 1984). Results are utilized to screen seed orchards and establish advanced generation breed populations.

We have started to process the information from the comprehensive controlled-crossing program (entitled: Studies of white-Engelmann spruce genetics. Kiss 1984). The first set of data confirmed and quantified previous observations regarding the deleterious effects of inbreeding in white and Engelmann spruce (Kiss 1986). Outcrosses averaged three times more filled seeds per cone than those of selfs. Outcrosses were 33% taller than selfs of the same families at the time of outplanting. Surprisingly, there were no clear-cut differences in average seed weight and germination percentages. In some families the selfs exhibited substantially poorer germination percentages than the outcrosses but in others the reverse was true. This inconsistency might be the result of the small sample used for germination tests. However, on the average, the overall germination of the forty selfs was 6% lower than the average of the outcrosses. Seed weight exhibited similar trends and the overall average seed weight of the outcrosses was 7% greater than the corresponding selfs. In conclusion, the data demonstrated that selfing significantly reduced the reproductive fitness in spruce and also reduced the first years growth rate very significantly.

CONTROLLED CROSSING PROGRAM

Second generation matings are nearing completion for the Prince George Selection Unit. 1991 was a poor year for cone production, thus only a minimal number of crosses was made.

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FOREST GENETICS ACTIVITIES AT THE UNIVERSITY OF BRITISH COLUMBIA

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JOHN CARLSON

My group is involved in several biotechnology projects related to tree improvement. The group presently includes two post-doctoral research associates (Dr. Lomas Tulsieram and Dr. Vidhya Amarasinghe), one research technician (Victor Luk) and five graduate students.

Genetic diversity at the DNA level

Jeff Glaubitz, PhD student, is using the molecular techniques of Polymerase Chain Reaction for DNA amplification and sequencing to study genetic diversity in conifers. A wide range of western red cedar populations is currently emphasized. The study will be extended to white, Engelmann and Sitka spruce, lodgepole pine, dawn redwood and gingko.

Bundit Ponoy, PhD student, is using Restriction Fragment Length Polymorphisms (RFLPs) to determine the extent of genetic variability in the mitochondrial genome of Douglas-fir. These data are being collected from 100 families representing a wide range of provenances in B.C. The molecular data are being compared with data on tree height, diameter and volume to determine if traits that are strongly uniparentally inherited derive from diverse cytoplasms.

Genetic maps for interior spruce

Dr. Tulsieram is responsible for our project on DNA markers for weevil resistance in spruce. The first genetic linkage maps for interior spruce will be produced. When these maps are complete, we will have molecular genetic markers covering all 12 chromosomes. We have taken the unusual approach of constructing genetic maps for each parent tree by analyzing haploid DNA. We are distributing kits of oligonucleotide primers to other labs across North America for use in the "RAPD" approach to genome mapping.

Garth Brown, PhD student, is constructing a molecular karyotype for white spruce and related spruce species and hybrids. Thekaryotypes are constructed by the physical mapping of DNA sequences onto white spruce chromosomes via fluorescence in situ hybridization.

Genetic diversity in white pine weevil

In collaboration with John McLean, forest entomologist at UBC, we are measuring the level of genetic variability between and among provenance collections of *Pissodes strobi* from three populations of Sitka, Engelmann, and white spruce and their hybrids using "RAPD" genetic markers. Dr. Aileen Wardle, a post-doctoral fellow with Dr. McLean, has established the technique with insects. The data will have implications for development of pest resistant planting stock.

Genetic engineering of Douglas-fir

Liwen Jiang, recent MSc graduate, has established a protocol for somatic embryogenesis from callus cultures of Douglas-fir. He also has demonstrated direct DNA transformation and is presently optimizing gene transfer via microparticle bombardment.

Confocal laser scanning microscopy (CLSM)

Dr. Amarasinghe will manage our CLSM facility as a community resource. We will use CLSM, which reveals internal structure without physical manipulation, in molecular karyotyping.

Lignin biosynthesis

Palitha Dharmawardhana, PhD student, is using CSLM to dissect the pathway for lignin formation. Mutants of Arabidopsis will be used to identify important regulatory genes. This information will be used in parallel studies on lignin biosynthesis in popular and spruce.

DONALD T. LESTER

Dr. Oscar Sziklai retired in December, 1989 and his position was filled by a wildlife biologist. Dr. Judy Loo-Dinkins joined Forsetry Canada (Maritimes) in 1991. The NSERC/ Industrial Chair in Forest Genetics and Tree Improvement will end in September, 1991. At present, there are intentions to re-establish two positions in forest genetics but no formal plans.

Program emphasis of the Chair has been on inheritance of wood quality, geographic variation in growth and physiological traits in genetically lesser known species, wide crossing in spruce and issues of genetic quality in seed orchards.

Wood Quality

A study was completed on pith-to-bark profiles of relative density in young Douglas-fir at 3 sampling heights. The objective was to determine whether increment cores taken below the traditional 1.3 m would accurately reflect genetic relationships at d.b.h. while producing higher juvenile-mature correlations as a consequence of more annual rings.

Data from cores collected at 0.7 m in the profile study were analysed for earlywood and latewood components of relative density. Genetic correlations were used to classify some trait pairs as compensatory (i.e. negatively correlated) while others were complimentary (positively correlated). Correlations were interpreted in terms of demands for carbon during different growth phases in the tree. Age trends were pronounced for some trait pairs.

Inheritance of shrinkage (longitudinal, radial, tangential), fibril angle, and grain angle is the PhD topic of Mathew Koshy. For Douglas-fir, he has found rapid decline in longitudinal shrinkage, and rapid increase in radial and tangential shrinkage as age from pith increases. Genetic effects at the clonal and family level are strong but decline with age for most traits.

Provenance and family variation

An MSc. thesis by Barbara Thomas covered cold tolerance in provenances and families from western white pine seed collected in coastal and in interior U.S. and B.C. Geographic variation in yellow cypress with emphasis on growth, and response to cold and drought stress is the topic for a PhD project by John Russell. Marilyn Cherry's PhD topic is geographic variation in western red cedar with emphasis on growth, morphology and cold hardiness.

Wide crossing in spruce

David Kolotelo's MSc. thesis reported on crosses between coastal and interior spruces in B.C. Height, phenology and cold hardiness were studied.

Genetic quality of orchard seed

Assistance was given to a team effort to develop a system for rating the expected genetic quality of orchard seed based on expected genetic gain and effective population size.

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PACIFIC FORESTRY CENTRE

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Keywords: Official seed certification and testing,

The seed testing and certification programs at the Pacific Forestry Centre are outlined. As a result of reorganization at the Pacific Forestry Centre, the seed research program has been discontinued.

OFFICIAL CERTIFICATION AND TESTING OF TREE SEEDS

As the Certifying Authority under the OECD scheme for the Pacific and Yukon Region, 127 certificates of provenance for 1354 kg of seeds in the source-identified category were issued in 1989. The majority of the seed certified was *Abies grandis* (Dougl.) Lindl. (951 Kg.) together with small amounts of *Picea sitchensis* (Bong.) Carr (56 kg.) and *Thuja plicata* Donn. (25 Kg.). In addition, 187 kg of *Pseudotsuga menziesii* (Moench.) Franco seeds were certified. Under the ISTA seed testing rules, 21 certificates of seed quality were issued in 1989; these represented over 750 kg of seeds from 10 species, with *Abies grandis* accounting for 60% of the total weight.

In 1990, 495 kg of source-identified category seeds were certified. This included *Picea sitchensis* (350 kg) and two other species. In addition 45 kg of *Pseudotsuga menziesii* were also certified. Concurrently, 31 ISTA certificates of seed quality, for 1752 kg of seeds of 9 species were issued; *Pinus contorta* Dougl., *Abies grandis*, *Pinus ponderosa* Laws., *Picea sitchensis* and *Pseudotsuga menziesii* were the major species.

The registration of seed orchards in the untested seed orchard category of OECD was continued with seven additional orchards registered in 1990 bringing the total in British Columbia to ten.

WESTERN WHITE PINE IMPROVEMENT PROGRAM FOR BRITISH COLUMBIA

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"OPERATIONAL" PROGRAM OF SELECTION AND TESTING

Following review of our program after four years of Provincial support, we have added "bark reaction" and "tolerant" categories to the criteria for parent trees. Selection of parent trees has continued in both planning zones, bringing the totals of selections to 332 on the coast and 225 from the interior zone. In addition, seeds from 51 U.S. coastal and 56 U.S. inland parents have been received; some families have been inoculated already. Support for tree selection, seed collection and extraction, and stock rearing is provided by the B.C. Forest Service.

Inoculation of open-pollination family stock has succeeded each year since 1987. Inoculation percentage ranges from 79% to 97%, based on all live seedlings. All families and all replications were inoculated successfully, with the yearly mean number of rust spots per seedling ranging from 10 to 51. Family means ranged from 2.1 to 78.3 spots per seedling. Healthy or rusted seedlings exhibiting abnormal reactions are transplanted for further observation and possible selection for the seed orchards. Losses to rust continue up to the age of 6, four years after inoculation.

Both the cultivated and wild *Ribes* groves are inoculated with rust annually to supply rust spores. Although mildew invaded the cultivated *Ribes* garden in 1990, we obtained enough inoculum from the wild groves.

Results of inoculations from 1986-1988 were summarized and used by Canadian Forest Products to plan an interim seed orchard for the coastal zone. Field agencies will be informed of inoculation results so that they can collect cones from the better trees.

RESEARCH PROGRAMME

Replacement of mortality and needed site maintenance were carried out on the plantations established in 1987-88. Assessment of these will start in 1992. Two other plantations, one containing widespread, unselected, populations, and the other to compare families already deemed poor to good from inoculation tests, were established on the coast in spring, 1991. Preliminary examination of some plantations established earlier by the B.C. Forest Service, Cariboo Region, indicated that winter damage may be more severe on Idaho sources than on local stock. More such plantations will be examined systematically in 1991. Research at U.B.C. found more fall frost damage to coastal than to interior seedlings, through the effects of latitude and elevation in zone were generally not important.

Preliminary analysis of the rust races trial found good inoculation success among families and replicates. Mean rust spots per seedling was highest for the "coastal mix" rust, whereas trees from the B.C. interior, not selected for rust resistance, gave a higher mean of spots per seedling than did the other sources, which contained some rust-resistant parents. The final assessment will be conducted in 1991.

Partial analysis of three seed crops from 15 parents in a single stand indicates inconsistent influence of parental outcrossing rate on seedling dimensions or total weight. Further analysis is required to determine the effects of estimated inbreeding on parental ranking.

Cloned DNA fragments suitable for use as probes to detect DNA variation in blister rust spore samples have been selected. Initial results indicate considerable heterokaryosis within individual aecial cankers. Variation among cankers on one tree appears similar to variation among cankers on different trees in a sampling area. Survey of variation among different sampling areas is continuing.

Resistance of white pine to *Endocronartium harknessii* is associated with cytological changes indicating an active response. *Endocronartium* spores germinate on white pine stems, and penetrate below the epidermis, accompanied by phenolic accumulation and wound periderm formation. The molecular basis of the response is being investigated.

Methods to extract needle proteins and to detect nanogram quantities of proteins have been developed. Sugar pine, whose genetics of resistance to this fungus is known, is being used in attempts to develop a molecular marker of resistance to the rust, based on proteins produced after rust inoculation of susceptible and resistant seedlings. An 18-kDa protein was detected in uninoculated sugar pine sampled in late October to November. Since this protein could not be detected in the samples collected in the following summer, it might be related to dormancy, e.g., frost hardiness. Trials are underway to produce monoclonal antibodies to the basidiospores of the rust fungus. These will be used primarily in immunocytochemical studies to elucidate the host-pathogen interaction. Monoclonal antibodies will be used also to study rust variation.

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RESEARCH AT FORINTEK CANADA CORP. RELATING TO TREE IMPROVEMENT

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Under the new organizational structure of Forintek, the Wood Science Department is now part of the Resource Utilization group in the Lumber Manufacturing Department. Two of our scientist members of CTIA have retired: Bob Kellogg and Clayton Keith. Forintek continues to work on studies related to tree improvement and a summary of these studies is presented.

RELATIVE DENSITY OF INTERIOR DOUGLAS-FIR AND WESTERN LARCH PARENT TREES IN BRITISH COLUMBIA TREE IMPROVEMENT PROGRAM

(1) Breast-height increment cores from 199 interior Douglas-fir parent trees located in the east Kootenay region of B.C. were assessed for wood density. The cores were cut at half the distance between the pitch and the bark, making two pieces of equal length. The mean density of the pieces closer to the bark was 0.428 with a standard deviation of 0.037; the mean density of the pieces closer to the pith was 0.405 with a standard deviation of 0.032. The first gives an estimate of the mature wood density; the second, of the juvenile wood density. When compared to other parent trees of the same species located in other interior seed zones, the mature wood of these east Kootenay trees had a lower density.

(2) Breast-height cores from 39 western larch parent trees were extracted sequentially with cyclohexane-ethyl alcohol and hot water and analyzed for wood density. The mean density of the first 15 rings (juvenile wood) from the pith was 0.447 with a standard deviation of 0.034. The mean density of the core from the 16th ring to the bark (mature wood) was 0.464 with a standard deviation of 0.025. The juvenile-mature wood boundary was made on the basis of an x-ray analysis of breast-height cores from 34 western larch parent trees which showed wood density to level out generally after the 10th-15th growth ring from the pith.

(3) Forintek is continuing to provide density assessment of western larch parent tree cores for the B.C. Ministry of Forests.

WOOD DENSITY OF CANADIAN TREE SPECIES

The result of this project is available from Forintek (Western Laboratory) under the publication name "Wood Density of Canadian Tree Species" by J.S. Gonzalez. The rept compiles wood density data of Canadian tree species grown in Canada and abroad, with a brief description of the geographic source and method of analysis of the test materials.

CORRELATION BETWEEN STEM GROWTH AND WOOD DENSITY IN YOUNG INTERIOR SPRUCE

This was a collaborative effort between Forintek and the B.C. Ministry of Forests. The objective was to assess the correlation between stem growth (diameter and height) at age 15 and core density (at about 30 cm above ground) of young interior spruce. Phenotypic correlation between wood density and stem diameter and height was generally negative and weak. Diameter and height were strongly and positively correlated.

GENETIC CONTROL OF DENSITY PROFILE IN YOUNG, DOUGLAS-FIR

This was a collaborative effort between Judy Loo-Dinkins (UBC Associate Professor) and Gonzalez (Forintek). The results of this work has been accepted for publication at the Canadian Journal of Forest Research. Preliminary results of this work were presented at the Wood Quality Working Group Session at the 22nd CTIA meeting in Edmonton, Alberta in 1989.

The trees representing 22 half-sib families at two progeny test locations were evaluated for relative density profile at 1.3 m (breast height), at 0.7 m and at 0.4 m above the ground. The profile was different for the first six or seven years from the pith at the different sampling heights, but the difference decreased with cambial age. Genetic correlation estimates were sufficiently high to indicate identical genetic control at the three heights, at least after age five, but heritability estimates were higher at the 1.3 m and 0.7 m heights than at the 0.4 m. The best sampling height of those tested was 0.7 m.

WOOD QUALITY AND HERITABILITY STUDIES IN A JACK PINE PROGENY TEST

Fifty half-sib families of jack pine from a 20-year old progeny test in the Ottawa Valley region were examined for wood quality characteristics. The characteristics included growth rate (height and diameter), stem taper, heartwood and compression wood content, wood density, extractives, and longitudinal shrinkage.

Results from a single plantation at Chalk River showed that the trees contained about 15 growth rings at breast height. Statistical tests for family association were not significant for tree height, diameter or total volume. Significant family associations were indicated for stem taper, heartwood content and wood density.

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CANADIAN PACIFIC FOREST PRODUCTS LIMITED TAHSIS PACIFIC REGION'S TREE IMPROVEMENT PROGRAM AND FOREST GENETICS ACTIVITIES

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Keywords: seed orchards, progeny testing, domestication and genetic diversity

The Saanich Forestry Centre has been involved in several tree improvement/forest genetics activities during the period covered by this report. These activities include seed orchard management, progeny testing, and various research activities.

Personnel changes occurred during 1989/91 with the retirement of both V.J. Korelus and W.J.B. Devitt. Bruce Devitt is currently Executive Vice-President of the Association of British Columbia Professional Foresters.

SEED ORCHARDS

Two new clonal orchards are in the establishment phase. These include a 2nd generation Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco] and a 1st generation western hemlock [*Tsuga heterophylla* (Raf.) Sarg.] seed orchard. In addition, all the Douglas-fir orchards are being rouged based on progeny test information supplied by the B.C. Ministry of Forests. Currently we are managing nine seed orchards of six different species: Douglas-fir, western hemlock, Sitka spruce [*Picea sitchensis* (Bong.) Carr.], yellow-cedar [*Chamaecyparis nootkatensis* (D. Don) Spach], and Pacific silver fir [*Abies amabilis* (Dougl.) Forbes] and one hedge orchard of western redcedar (*Thuja plicata* Donn). Crop management includes: supplemental-mass-pollination (SMP) and/or bloom delay for Douglas-fir and SMP for all other species. In 19912, an elite Douglas-fir seed crop was produced through controlled crosses among the high breeding value clones.

PROGENY TESTING

The high and low elevation Douglas-fir breeding populations are being tested by conventional methods complemented with early testing trials. Sitka spruce and western hemlock are being tested using wind-pollinated families. Polymix crosses for western hemlock were produced for the Ministry for their testing program. Breeding activities for all species are co-ordinated with the B.C. Ministry of Forests breeders to avoid duplication.

RESEARCH

Several research projects were completed during the period covered by this report (see Publications). These include: seed orchard genetics, early testing, seed biology, molecular genetics, mating systems, and fertilization of Douglas-fir families. Currently, the impact of domestication on the genetic diversity is under investigation. These research projects are funded in part by the B.C. Ministry of Forests, Canadian Pacific Forest Products Limited, CIDA, and the Science Council of B.C.

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APPENDICES

C.T.I.A./A.C.A.A. 23rd Business Meeting Minutes

Conference/Excursion Photo-ops

Participants of the C.T.I.A. 23rd Meeting

C.T.I.A. Active Members

C.T.I.A./A.C.A.A.
23rd BUSINESS MEETING
MINUTES

Gordon Murray chaired the 23rd Business Meeting of the CTIA/ACAA held in the Delta Inn, Ottawa, Ontario on Wednesday August 21, 1991.

The meeting started with a minute's silence in memory of Dr. Armand Corriveau, Dr. Carl C. Heimburger and Jack Pitel, who will be sorrowfully missed.

1.0 Adoption of the minutes of the previous meeting

(as printed in the proceedings from the 22nd meeting (Part I))

Motion: The Minutes of the 22nd Business Meeting be approved as published.

Moved by: Jerry Klein
Seconded by: Francis Yeh
Carried.

2.0 Membership

2.1 Honourary Membership

A letter was submitted to Chairman Gordon Murray from Steen Magnussen, Ben Wang, Peter Copis and Gordon Murray requesting nomination of **Dr. C.W. Yeatman** for a honorary membership of the Canadian Tree Improvement Association as an appreciation of his tireless efforts to promote the concept of sound genetic practices and tree improvement in Canadian Forestry and his never failing support for this association.

Moved by: Dr. Don Fowler
Seconded by: Dr. Alex Mosseler
Carried.

2.2 New Active Members

Nomination of new Active Members are as follows:

Jean Bousquet	Universite Laval Ste. Foy, Quebec
Franco Di-Giovanni	Canadian Climate Center Egbert, Ontario
Gordon Folk	Dept of Natural Resources Dugald, Manitoba
Michele Fullarton	N.B. Dept. of Natural Resources Fredericton, N. B.
Doug Hunt	Repap Manitoba Inc. The Pas, Manitoba

Kurt Johnsen	Forestry Canada Chalk River, Ontario
Dennis Joyce	Ontario Ministry of Natural Resources Sault St. Marie, Ontario
C.H.A. Little	Forestry Canada Fredericton, N. B.
Harold Peacock	Abitibi-Price Inc. Pine Falls, Manitoba
D. G. Steeves	N.B. Tree Improvement Council Fredericton, N.B.
Katherine Yakimchuk	Pine Ridge Forest Nursery Smoky Lake, Alberta

Motion: That the nominated new active members be elected.
Moved by: Francis Yeh
Seconded by: Steen Magnussen
Carried.

2.3 New Corresponding Members

The following were recorded.

Corrine Andriuk	Pine Ridge Forest Nursery Smoky Lake, Alberta
Nathan Antoniuk	Pine Ridge Forest Nursery Smoky Lake, Alberta
Greg Branton	A.N.C. Timber Ltd. Whitecourt, Alberta
Brian Carnell	High Level Forest Products Ltd. High Level, Alberta
Christine Hansen	Pine Ridge Forest Nursery Smoky Lake, Alberta
Gordon Lehn	Millar Western Industries Ltd. Cochrane, Alberta
Steve Luchkow	Daishowa Canada Co. Ltd. Peace River, Alberta
Bruce MacMillan	Weyerhaeuser Canada Ltd. Edmonton, Alberta
Luc Masse	Gouvernement du Quebec Charlesbourg, Quebec

Pierre Perinet	Min. Energie et Ressources Service de L'Amelioration des Arbres Ste. Foy, Quebec
Diane Renaud	Miller Western Industries Ltd. Whitecourt, Alberta
Bill Rugg	Weldwood of Canada Ltd. Hinton, Alberta
Doug Sklar	Alberta Pacific Forest Ind. Ltd. Edmonton, Alberta

3.0 Business arising from the minutes

3.1 Tree Crown Research

The executive was asked (by the Tree Seed Working Group) to send suitable letters to federal, provincial, and other appropriate research-management agencies, stressing the urgent need for research on management of tree crowns in seed orchards.

Action: A suitable letter was sent by Steen Magnussen, to all forestry faculties in Canada, all provincial governments and all Forestry Canada establishments.

Response: Few, containing only general support for the idea. Nothing concrete.

3.2 Educational Committee

All forestry faculties were encouraged to nominated a student for participation of the 23rd CTIA/ACAA meeting. Meeting costs and travel funds were provided to the following students.

Carmelle Beaulieu	(Universite Laval)
David Allen Kollotello	(Univ. of British Columbia)
Cynthia Carswell	(Univ. of New Brunswick)
A. van Niejenhuis	(Lakehead University)
Lance Ollenberger	(University of Alberta)
Beth Beatson	(University of Toronto)
Philippe Thériault	(University of Moncton)

4.0 Chairperson's Report

My term as Chairperson has been made relatively easy by virtue of the excellent work done by the other committee members, Steen Magnussen, Tim Boyle and Ron Evers. Also, we have received outstanding support from Joy Lavereau and Bill Selkirk at Petawawa National Forestry Institute, and Cathy Nielson, Ontario Ministry of Natural Resources, Brockville.

To all who worked so hard and so effectively to make this meeting a success, I offer my sincere thanks.

Thanks are also due to Forestry Canada and the Ontario Ministry of Natural Resources for their support of this meeting and the associated CTIA activities.

Jim Coles, CTIA secretary for many years, has tendered his resignation, and will be taking up a challenging new assignment in the ASEAN-Canada Forest Tree Seed Centre in Thailand. On your behalf I will write Jim a letter of appreciation for all that he has done for the CTIA. The issue of a replacement for Jim will be raised later in the meeting.

I am pleased to see that the United States were well represented at this meeting, and I appreciate the fact that the North American Quantitative Genetics Association agreed to have its meeting at the same time and place as the CTIA. There is certainly the recognition within the CTIA and the Society of American Foresters of the benefits of cross border participation in these meetings, and I hope that future meetings will encourage this.

5.0 Treasurer's Report

The financial statement, as of June 30, 1991, was prepared by Treasurer Steen Magnussen and was tabled for membership information and acceptance by the Treasurer.

Financial statement for the period of May 10/89 - June 30/91*

Assets (Cash: $4,317.78, GIS: $18,597.78 - May 10, 1989:	$14,280.00
Income:	
Interest earnings (GIC, Account)	$4,008.32
Surplus from 22nd meeting	$1,231.06
Back pay of advance to 22nd meeting	$1,000.00
Contributions	
Canadian Pacific Products Ltd.	$500.00
Ont. Forest Industries Association	$200.00
Weyerhaueser Canada Ltd.	$250.00
Total Income	$7,189.38
Expenditures:	
Bought GIC (net & addition)	$2,500.00
Printing of stationary	$368.88
Printing cost of announcement and programme	$119.94
Service charges for safety deposit box	$61.54
Total expenditures	$3,050.36
Assets: (Cash + GIC) June 30, 1991:	$22,736.80

*. excluding expenditures and registration fees for the 23rd meeting

Motion: That the financial statement be accepted as presented.
Moved by: Yoursy El-Kassaby
Seconded by: Francis Yeh
Carried.

6.0 Editor's Report

The 1989 membership reports and proceedings from the 22nd meeting in Edmonton were printed and distributed to our members during the first months of 1990. The Science and Sustainable Development Directorate and the Petawawa National Forestry Institute of Forestry Canada paid all costs of printing and distribution of the two volumes. Over 400 copies of each were mailed.

This year's membership reports have been submitted by all of you and we expect to publish them by the end of 1991.

Our current agreement with Forestry Canada regarding support for printing proceedings and membership reports ($5,000 annually) expires with the fiscal year 1992/93. Negotiations to obtain a renewed commitment will commence in the first half of 1992.

Our membership list has been purged of members who did not confirm their desire to remain on our membership list. We now have a membership of 375 in Canada, 94 in the U.S.A. and 123 in other countries (total: 592). Active members count is 131.

7.0 Education sub-committee report

Motion: Policy of support for Student Attendance at CTIA Meetings

Whereas it is the objective of the Canadian Tree Improvement Association to promote the use of scientifically and technically sound genetic practices in Canadian forestry,

and

Whereas the membership of the CTIA has expressed its wish to encourage studies and research in forest genetics and tree improvement in schools of forestry at Canadian Universities, and in other departments in Canadian Universities with programs relevant to the objectives of the C.T.I.A.

be it resolved that

That Executive Committee of the C.T.I.A. will make sufficient funds available to cover the costs of attending each C.T.I.A. meeting for at least seven students from schools of forestry in Canadian Universities, or from other departments with programs relevant to the objectives of the C.T.I.A.

and that

These awards should be made subject to the following guidelines:

1. The procedure for selection of recipients of these awards will be determined for each meeting by the Executive Committee in consultation with the Education Sub-Committee of the C.T.I.A.
2. Awards will be made to students at the graduate or undergraduate level whose interests and activities most closely meet the objectives of the C.T.I.A.
3. Students supported will be from as many universities as possible.

4. Students supported will be encouraged to present a poster or paper at the meeting.

5. Invitations to apply for support to attend the meeting will be sent to a faculty representative at each of the schools of forestry at Canadian Universities, and to other university departments identified by the Executive Committee.

6. Invitations to apply for support should be sent well in advance of each meeting to leave ample time for completion of the selection process and for making the economical travel arrangements.

7. The Executive Committee is expected to raise funds to cover the cost of this program for each meeting.

8. In the event that there is a shortage of applicants who meet the selection standards set by the Executive Committee or financial constraints, the Committee may opt to withhold some awards.

Moved by: Francis Yeh
Seconded by: Alvin Yanchuk
Carried.

8.0 Working Group Reports

8.1 Tree Seed Working Group

The Tree Seed Working Group held its Biennial Business meeting yesterday, 20th of August, with 17 present.

The Working Group has continued its regular activities during the past two years. The Newsbulletin has been issued each fall and spring. The issues have run to about 15 pages each, and have been distributed to 185 addressees. This publication is proving to be an excellent means of disseminating information and of keeping membership informed of many aspects of seed-related activity. I wish to pay tribute to the work of the Editor, Hugh Schooley: his is doing a first-class job of coordination, and says that the job is now easier as many items are being submitted voluntarily. The Working Group expresses its thanks to Forestry Canada for its assistance in production and distribution of the Newsletter. The Working Group organized and conducted, at this CTIA/ACAA meeting, a workshop. The theme was on the topic brought to the attention of CTIA/ACAA at its last meeting, 'Crown Management for sustained, easy to reach, cone production'. Despite having the number of designated speakers cut in one-half because of economic constraints, the workshop was well-received and successful.

A new initiative was to accept, under the umbrella of the Tree Seed Working Group, a second Working Party, this one on Seed Processing and Testing. The idea for such a national body was instigated by provincial personnel. Its formation followed a letter poll I conducted of 25 persons, and a meeting, yesterday, of 20 interested persons. The Chairman of this Working Party is Dave Bewick, Atlantic Forest Seed Centre. He has a core of six others who will work with him to formulate objectives and an organizational framework. The Working Party will use the Working Group's Newsletter as one means of interaction among its members.

It is a concern of the Working Group that all its members become fully aware of the purpose, thrust, and details of the proposed Canadian Tree Seed Regulations, and have opportunity to provide input for this development, as appropriate. Tim Boyle is the person to contact on this issue.

Finally, I must report that the new Chairperson of the Tree Seed Working Group is Dr. Guy E. Caron.

Respectfully submitted,
Graham R. Powell
Chairperson 1987-1991

8.2 Wood Quality Working Group

Dr. Clayton Keith, retired in early 1990 from his position as Research Scientist with Forintek Canada Corporation. He also decided to step down as Chair of the Wood Quality Working Group (1989-1991). Josefina Gonzalez, the Vice-Chair, assumed the position. The Secretary, Rod Savidge, also had to resign in June, 1991 to go on sabbatical leave in England. On behalf of the Group, I would like to express our thanks and appreciation to Rod for his support and contribution in the preparation of the News Bulletin.

Two issues of the News Bulletin were mailed out to about 100 people.

A one-half day session on wood quality was held during the 23rd biennial conference in Ottawa. Five papers were presented: four on wood density and one on branch diameter heritability. Two volunteered papers had to be cancelled due to illness of the author.

New officers (1991-1993) for the group are Chair: Josefina S. Gonzalez; Vice-Chair: Yousry El-Kassaby; Secretary: Alvin Yanchuk. The group discussed possibilities for increasing member participation. The group will try to increase the News Bulletin issues and attract more papers for the next biennial conference.

9.0 Election of new executive

The following slate of officers for election to the 1991/93 CTIA/ACAA executive:

Chairperson:	Kathy Tosh N.B. Dept. of Natural Resources & Energy
Vice-Chairperson:	Dale Simpson Forestry Canada
Vice-Chairperson Arrangements:	Greg Adams J.D. Irving Ltd.

Moved by: Ron Smith
Seconded by: Kurt Johnsen
Carried.

Treasurer: Steen Magnussen
Forestry Canada

Moved by: Yousry El-Kassaby
Seconded by: Alvin Yanchuk
Carried.

Editor: Joy Lavereau
Forestry Canada

Moved by: Jerry Klein
Seconded by: Yousry El-Kassaby
Carried.

Executive Secretary: Joy Lavereau
Forestry Canada

Moved by: Francis Yeh
Seconded by: Gordon Murray
Carried.

10.0 Future meetings

10.1 Location of the 1993 meeting

Kathy Tosh confirmed that New Brunswick Department of Natural Resources & Energy will host the 24th biennial meeting in Fredericton.

10.2 Location of the 1995 meeting

Motion: That the 1995 CTIA/ACAA meeting be hosted jointly by British Columbia Ministry of Forests and W.F.G.A., and will be held in Victoria.

10.3 Location of the 1997 meeting

Motion:Tentative support from Ariane Plourde and Gaetan Daoust to hold the 1997 meeting in Quebec City.

11.0 Other Business (None)

12.0 Adjournment

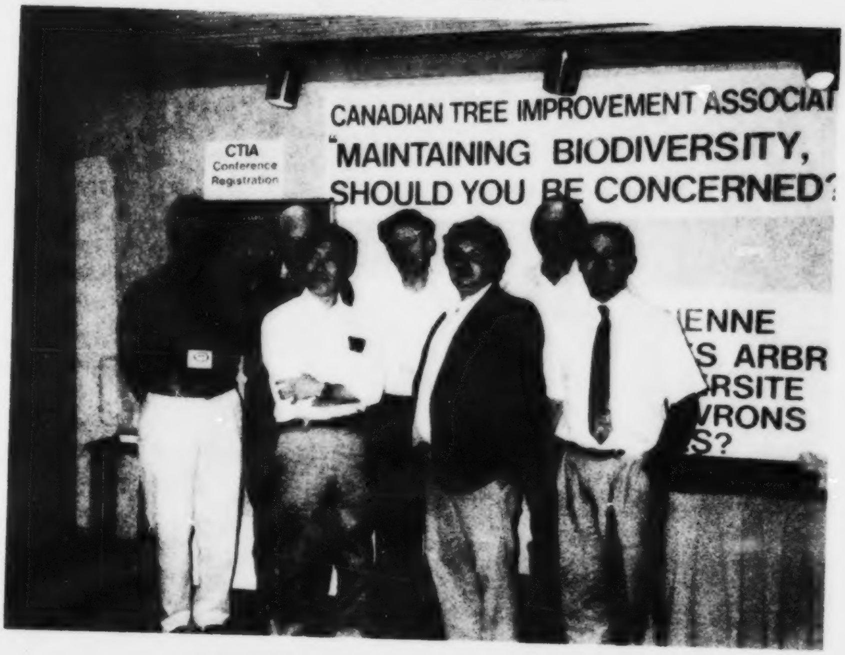
Motion: That the CTIA/ACAA members would like to thank the 1989/1991 executive for their efforts over the past two years and for an exciting and successful meeting.

Motion: That the 23rd business meeting of the CTIA/ACAA be adjourned.

Moved by: Francis Yeh.
Carried.

PHOTO-OPS

THE CONFERENCE


CANADIAN TREE IMPROVEMENT ASSOCIAT
"MAINTAINING BIODIVERSITY,
SHOULD YOU BE CONCERNED?
CTIA Conference Registration
ENNE
S ARBR
RSITE
VRONS
S?

C.T.I.A.'s BIO-CHOIR...1 and ah 2 and a 3

Don Fowler, Bill Libby, Gene Namkoong, Stan Krugman,
Brad Fraleigh, Steen Magnussen, Gordon Murray

D..I..V..E..R..S..I..T..Y..
Get It??

Tim Boyle

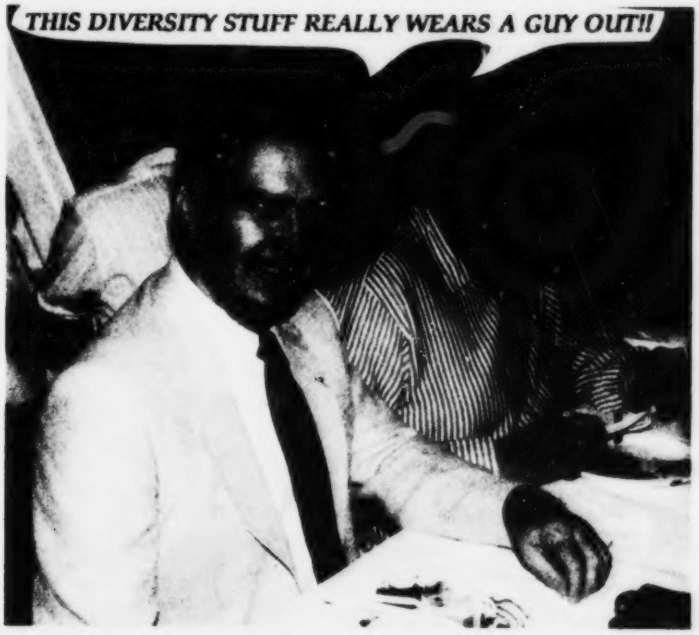
LA CRUISE

OK, WHO BROUGHT THE FISHING RODS?

IS ANYBODY WATCHING US?

JUST REMEMBER CATHY, THE LIFEJACKETS ARE OVERHEAD.

Kathy Tosh and Cathy Nielsen

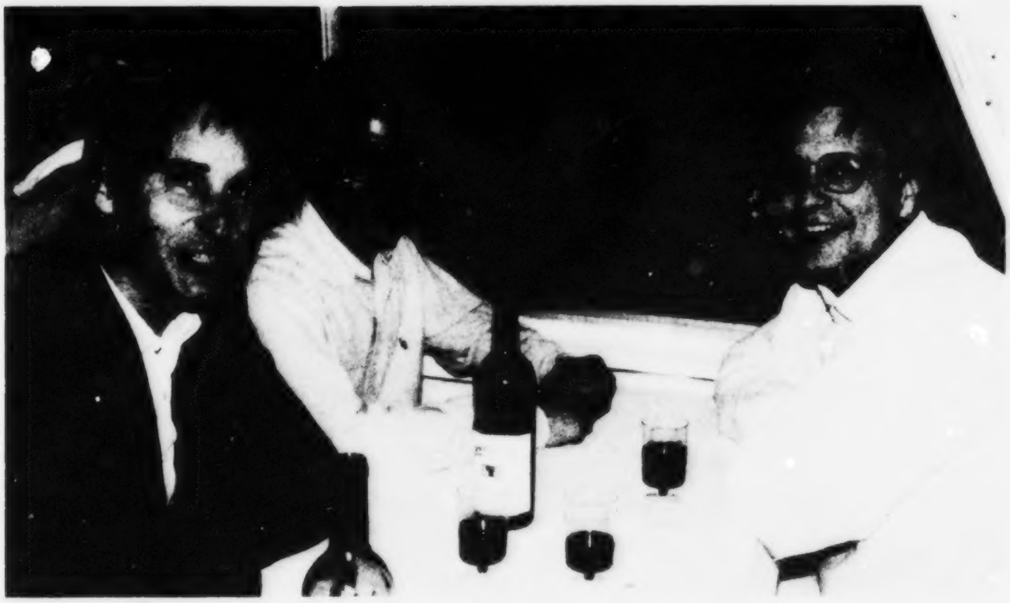

THIS DIVERSITY STUFF REALLY WEARS A GUY OUT!!

IF YOU DIDN'T TALK
SO MUCH PETE, YOUR
FOOD WOULDN'T GET COLD!

*Gordon Murray
and Peter Hall*

FINALLY, SOMETHING
INTERESTING:
POLLEN CAKES!

Jim Roberds, Gene Namkoong and Frank Di-Giovanni



HOW MUCH DIVERSITY CAN YOU GENERATE FROM A, G, T AND U?
THEY KNOW, BUT WILL THEY TELL????

Ben Sutton, Philippe Theriault & Pierre Charest

And, this year's
BIO-KING
and
BIO-QUEEN...

Don Fowler
and Linda Gordon

I'M NOT BELIEVING ANY OF THIS (bs).

I'M STILL WORKING ON THIS ONE!

Kurt Johnsen
and Michele Fullerton

WHICH WAY NOW?
(DIVERSITY WHICHEVER WAY YOU GO)

Danny Haines
David Kollotello
Steen Magnussen
Chris Atack

DAMN THAT CAVITY.

DRAW!

Graham Powell
with nervous onlookers.

C'MON DAD. DO YOU BELIEVE ALL THIS... BIO-DOO-DOO.
SCIENCE CAN BE SCARY... BUT DAD IS HERE.

Alex Mosseler

BIO-DIVERSITY-LET'S ALL TAKE A MOMENT AND PONDER.

OTTAWA VALLEY CHARM

DUELLING DANCERS FULL BLAST AT P.N.F.I.

GOOD FOOD, GOOD FRIENDS, GOOD FUN.

PARTICIPANTS OF THE CANADIAN TREE IMPROVEMENT ASSOCIATION TWENTY-THIRD MEETING - OTTAWA, AUGUST 1991

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